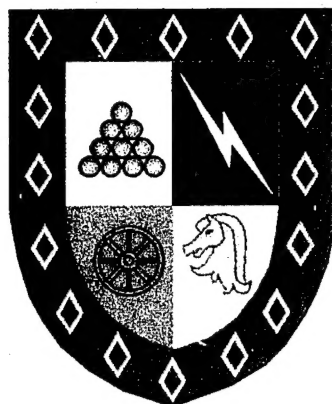
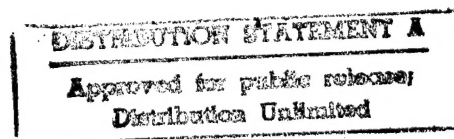


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**CRUSADER**



The Self-Propelled Howitzer  
(SPH)  
and  
Resupply Vehicle  
(RSV)

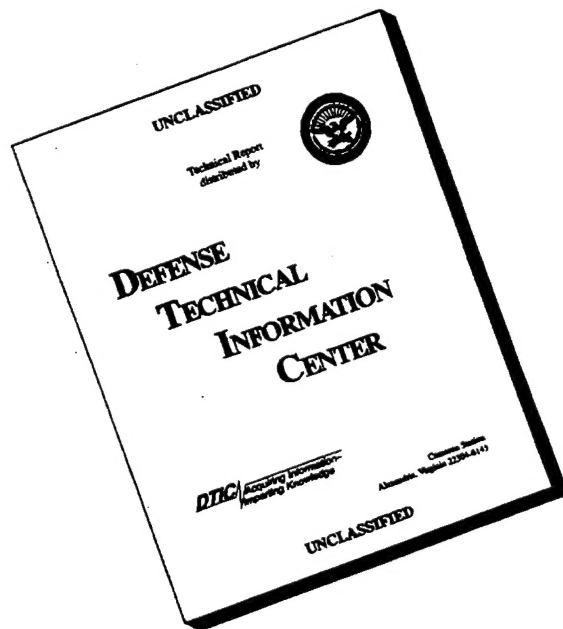


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# **Crusader**

## **Acquisition, Streamlining and Lessons Learned Report**

**November 30, 1995**

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**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

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**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## FOREWORD

Unlike conventional solid propellant artillery cannons, whose performance is predetermined by the propelling charge, the Regenerative Liquid Propellant Gun (RLPG) tailors its performance by altering its interior ballistics through its ability to reconfigure its components to precisely achieve the desired muzzle velocity. **The RLPG has always been programmed as the Army's choice as an integral part of the total Crusader SPH and resupply system from a number of perspectives: technical and tactical fire control; propellant storage, pumping and management; automatic ammunition handling; power consumption and distribution, mobility platform stabilization; energy dispersion, vehicle configuration and structure; and computational demands.** Because of the risk involved with the RLPG, the Project Manager for Crusader is ensuring that a solid propellant backup system is developed and tested in parallel with the RLPG.

On 10 November 1994, AFAS/FARV became Crusader, one system, with AFAS known as the self-propelled howitzer (SPH) and FARV known as the resupply vehicle (RSV). This documentation of the acquisition, streamlining, and Lessons Learned process of Crusader was done in a chronological manner by chapter as events happened. Therefore, the term AFAS/FARV is used through the 10 November date in some instances.

Throughout this report, the terms Integrated Product Team/s (IPT/s), Integrated Product Development Team/s (IPDT/s), and Product Development Team/s (PDT/s) are used interchangeably. This is because the concept was being developed simultaneously among industry, OSD, the Army, and the office of the PM Crusader.

The Independent Government Cost Estimate (IGCE) for the US Army Crusader Self-Propelled Howitzer/Resupply Vehicle program supports the Demonstration/Validation Phase of this Acquisition Category I weapon system program.

This document has been written as a "living record" of the Crusader program and as such, the back of each page is annotated "Additional Lessons Learned, Updating, and Notes for Crusader". Readers and users (throughout DoD) of this document are encouraged to list any lessons learned or applicable information concerning the Crusader program on these pages and send copies to the Project Manager, Crusader, Building 3159, Picatinny Arsenal, NJ 07806-5000 or Facsimile: DSN 880-2221, Commercial (201) 724-2221.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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## INTRODUCTION

The following Crusader program description is adapted from the Introduction to the Crusader Dem/Val RFP.

The Crusader is a "system of systems" consisting of a 155mm self-propelled howitzer (SPH) with increased capabilities over the current M109 SPH fleet, and a resupply vehicle (RSV) with increased capabilities over the M992 FAASV. The howitzer achieves increased lethality with the Regenerative Liquid Propellant Gun (RLPG) and a capability for independent fire mission execution using digital electronics and state of the art C3 features. The RSV provides the howitzer "one stop shopping" for ammunition, propellant and fuel without directly exposing the crew of either vehicle to enemy weapons. Both vehicles, powered by a Perkins diesel engine, provide significant increases in mobility and survivability over the current self-propelled fleet.

The Crusader will be fielded as a single system and a single contract will be awarded for the Demonstration/Validation Phase. United Defense Limited Partnership (UDLP) has been selected as the prime contractor. It has teamed with Teledyne, Lockheed Martin and General Dynamics, all of whom worked on the Concept exploration and Development Phase, to form a unique capability, allowing the Army to capitalize on earlier investments and provide continuity in technology maturation.

The Army is using an Integrated Product Development (IPD) approach to manage this acquisition, using partnering and teamwork to forge long-term relationships. The Army seeks a congruous view of the best balance of performance, cost and schedule. The IPD teams, consisting of government and contractor personnel, will work closely together throughout the requirements analysis, simulation, design and prototype assembly efforts. The actual Scope of Work for the upcoming contract will be developed in an IPD environment.

Crusader acquisition strategy differs from the traditional approach. In the spirit of streamlining and acquisition reform, the approach calls for a single development effort with periodic performance-oriented reviews. Phase I, the Simulation and Component Maturation Phase, is a design requirements development and validation effort with the objective of synthesizing the SPH and RSV requirements for the Crusader System. Simulations, models, emulators and experimentation will be employed to validate design.

The objective of the Prototype Fabrication and Demonstration Phase (Phase II) is to verify that Operational Requirements can be achieved. This will be done through the integration of subsystems into prototypes and an ensuing user evaluation effort. During this stage the Army expects critical subsystem and limited prototype development and user testing of the RLPG, the propulsion system, the vehicle

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

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electronics architecture, soldier-machine interface, and contractor-identified critical items prior to integrating them into a prototype. The focus of these efforts is to reduce performance and integration risk and assure a successful prototype demonstration.

Throughout program documentation the Army has documented "what" the Crusader must do to meet the projected threat. The Army has purposely avoided technical "how to", detailed schedules, and imposition of Military Specifications and Standards. Furthermore, the contractor has the latitude to propose less than the objective system performance during Phase I & II. However, as shown below, there are criteria which represent essential performance levels to support a favorable decision to transition to Phase III.

Current Program Milestones include:

Completed Milestone I Defense Acquisition Board (DAB)	Nov 94
Awarded Requirements Analysis & Component Maturation Contract	Dec 94
Dem/Val Contract Award	Dec 95
PEO IPR	Jun 97
DAE IPR (EMD Decision)	Apr 00
LRIP IPR	Aug 03
FUE	Jul 05

A complete program schedule is shown in section 36.

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## **CHAPTER I**

### **ACQUISITION, STREAMLINING AND LESSONS LEARNED**

**Additional Lessons Learned, Updating, and Notes for Crusader**

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## 1. BACKGROUND

### A. Project Structure

#### i. Objective

The Advanced Field Artillery System (AFAS) and the Future Armored Resupply Vehicle (FARV) project objective is to develop and field an artillery weapon system to satisfy deficiencies identified in the January 1991 Army Battlefield Development Plan 1994-2008 (U); the January 1993 Army Modernization Plan, Volume I and Volume II, Annex G (Fire Support); and the June 1993 AFAS and FARV Operational Requirements Documents (OD).

#### ii. System Evolution

The beginning of the current AFAS and FARV programs was during the evolution of the Army's Armored Family of Vehicles, Heavy Forces Modernization, and Armored Systems Modernization (ASM) - Future programs. These programs forecasted the modernization of the combat, combat support, and combat service support vehicles of the Army's heavy divisions and brigades based upon the concept of common mobility components and interchangeable mission peculiar modules on one of two similar but different chassis. The concept included the assumption that all the systems of the division would be replaced concurrently. The analyses of these projects recommended critical affordability challenges and sanctioned the restructure of the Army's objectives. That restructure resulted in the prioritization of the missions of the division's vehicles and that prioritizing of the vehicles to be developed.

#### iii. Vehicle Variants

Package One vehicles included the Block III Future Main Battle Tank (BLK III), the Future Infantry Fighting Vehicle (FIFV), the Combat Mobility Vehicle (CMV), the Advanced Field Artillery System (AFAS), the Line of Sight Anti-Tank (LOSAT), and the Future Armored Resupply Vehicle-Ammunition (FARV-A). The project initially conceived two weight/size designs, heavy and medium, each with two armor protection level variants, also heavy and medium. Budget constraints allowed the new development of only the heavy weight chassis. The medium weight chassis was to be a derivative of the Bradley Fighting Vehicle System (BFVS) family of vehicles. The large number of BLK III vehicles to be produced and its demanding mission profile argued it as the lead variant of the family. Therefore, the initial acquisition proceeded with the 1990 competitive award of two contracts for the BLK III tank and the heavy common chassis. A subsequent down select between the two concepts resulted in a BLK III prime contractor being the provider of chassis structures and components for all subsequent variants that would utilize the heavy common chassis.

#### iv. Threat

With the collective assessment of the diminished global threat, especially in Central Europe, the combat proven superiority of the M1A1 tank in Operation Desert Storm, and the



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anticipated decrease in Defense resources for conventional force modernization, a reappraisal of the ASM - Future project was conducted.

v. *ASM - Future System Restructure*

In 1992, the ASM - Future project was restructured, indefinitely deferring the BLK III and FIFV. It limited the CMV development to a near-term and M1-based solution (i.e., Breacher) and returned the LOSAT to the technology base for continued research. It also placed FARV on a heavy chassis and focused the project on AFAS and FARV. This redirection reflected growing Congressional concerns over pre-existing indirect fire support deficiencies while Operation Desert Storm revealed shortcomings in US Army cannon artillery. Many nations have cannon artillery systems superior to our M109 series howitzers, including the M109A6 Paladin. Through training exercises and actual combat, the mobility, firepower and survivability differential between the M109-series howitzer, its supporting resupply vehicle (the Field Artillery Ammunition Support Vehicle [FAASV]) and other more modernized elements of the maneuver force have become markedly evident. By all credible analyses, the 1950's vintage platform of the current and product-improved M109-series howitzers has reached the limits of its potential growth.

vi. *The AFAS/FARV System*

The AFAS/FARV will be the indirect fire support system providing direct and general support to the armored and mechanized maneuver forces on the future battlefield. The AFAS/FARV is one system, comprised of two unique and distinct major Defense acquisition systems—AFAS and FARV—each designed to operate in tandem on the battlefield through specific interfaces and sharing commonality of subsystems to the maximum extent practical. The AFAS will provide close, tactical, and operational fires during both offensive and defensive operations. The AFAS will be a 155mm self-propelled howitzer with significantly increased capabilities over the current M109-series fleet. It will provide increased rate of fire, hold more ammunition, be more responsive and survivable on the battlefield, with reduced manpower requirements (three crewmen in each vehicle vice four). The AFAS/FARV will provide significantly increased lethality, mobility, and survivability, allowing for flexibility in tactical employment of howitzers in sections, platoons, batteries and battalions, as well as the added capability of independent mission execution.

vii. *Battlefield Suitability*

The result of these enhancements is that the AFAS will provide close, tactical and operational fires during offensive and defensive operations well into the 21st century. The Mission Needs Statement (MNS) described an urgent need for a more lethal, mobile, survivable, longer-range and less manpower-intensive cannon. The MNS examined alternatives for modernizing the self-propelled howitzer fleet, including block improvements to the existing systems, and concluded that development of a new system is the most effective means of meeting the needs of the future. AFAS will resolve the deficiencies of 6,9,16,28, 51, and 88 in the Battlefield Development Plan 1994-2008.

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

### *viii. Quantities*

Together, AFAS and FARV will operate on the battlefield as one system. When fielded, this system displaces the M109A6 Paladin and its accompanying Field Artillery Ammunition Support Vehicle, the M992A1/A2 (FAASV). A total of 824 AFAS and 824 FARV systems will be fielded to rapidly Deployable and Forward Deployed Forces. Paladin and FAASV will then cascade to Initial reinforcing, Follow-on reinforcing, and CONUS Land Defense Forces. The specific quantities, prototypes and deliverable end items, by phase, are shown in the following table:

Vehicle	DEM/VAL Phase I/II	EMD Phase III	LRIP Phase III	Vehicle Production		
	FY95-00	FY01-03	FY03-05	FY05	FY06-10	FY11
AFAS	2	10	40	75	120/yr	109
FARV	2	10	40	75	120/yr	109

### *ix. Personnel Reduction*

The personnel analysis completed by TRAC-Fort Lee identified the required number of soldiers at the unit, and direct support (DS) and general support (GS) levels. Unit totals shown below include all battalion personnel assets (crew, maintenance, administrative, survey). DS and GS quantities in the chart are maintenance personnel in support units outside the battalion. Results indicate a potential personnel reduction of 156 soldiers per AFAS/FARV battalion over a Paladin/FAASV battalion and 158 soldiers over a Paladin(I)/FAASV(I) battalion. Based on an Army-wide 20-battalion force, this equates to approximately 3,000 soldiers. The maintenance personnel estimates were based on preliminary Reliability, Availability, Maintainability (RAM) data provided in the materiel developer's analysis in November 1993 and validated by the Army Material Systems Analysis Activity (AMSAA). RAM data updates have been provided to AMSAA and are currently under review. It is possible that there could be some fluctuation in the number of maintenance personnel required as a result of the independent review. Therefore, the potential exists for some variance in military personnel costs in the life-cycle cost estimate.

PERSONNEL COMPARISON - 3 X 8 BATTALION					
Alternatives	Paladin Base Case	Paladin (I)	AFAS/FARV	AFAS/PLS	AFAS/FVS
Unit Total	609	599	464	461	464
DS	31	43	20	20	20
GS	3	4	3	3	3
TOTAL	643*	646	487*	484	487

\* AFAS/FARV saves 156 personnel compared to the Paladin/FAASV battalion. Based on a 20 battalion AFAS force, the AFAS/FARV fleet requires about 3,000 fewer personnel Army-wide.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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### B. Lessons Learned

#### LESSONS LEARNED - BACKGROUND

- Look to battlefield experience to determine priorities for system improvements and deficiencies.
- May need to reevaluate one-for-one 824 to 824.

## 2. MANAGEMENT

### A. AFAS

#### i. *Project Manager (PM)*

Colonel David Napoliello (FA) was selected as the first PM, AFAS in May 1989 and continued in this position through January 1994. Until his departure, AFAS and FARV had separate Project Managers. Both COL Napoliello and his Deputy, Mr. Eugene Del Coco were concerned with the current and future status of AFAS and began developing a project that would best meet the requisite needs of the Army field artillery program.

#### ii. *Integrated Product Teams (IPTs)*

Of immediate concern was the problem of maturing the Regenerative Liquid Propellant Gun (RLPG). The center of excellence for this gun was with Martin Marietta in industry and not with the Army. It was Mr. Del Coco's desire to have people from within the Army get involved with industry; hence, the PM's Integrated Product Teams (IPTs) concept was formulated. Newly assigned LTC William O. Henry (OD) had graduated from the Defense Systems Management College Project Management Course at Fort Belvoir, Virginia, in December 1991 and was a classmate of COL Gary Kelly, who was connected with Air Force MG James Fain and the F-22 Advanced Tactical Fighter project. The F-22 employed concurrent engineering, IPTs, and the principles of draft MILSTD 499-B, a Systems Engineering document. The Aeronautical Systems Center at Wright Patterson Air Force Base is the leading proponent for IPT systems engineering. Because of this, LTC Henry was designated as the PM's lead for looking at industry and other elements of the Department of Defense (DoD) for fully implementing IPTs within AFAS/FARV.

#### iii. *IPTs Implementation*

LTC Henry spent the Spring of 1992 discussing IPTs with industry and within DoD. He started with the Defense System Management College (DSMC) at Fort Belvoir, the DoD proponent, to obtain the latest information and any success examples, one of which was the Air Force's F-22 project. Other programs looked at were Saturn in the automobile industry, Boeing 777, and Light Helicopter, Experimental (Comanche). LTC Henry led a team that visited the F-22 project office during the first week of September 1992. The Team received briefings from MG James Fain, the F-22 Systems Program Director, on his guiding principles/management

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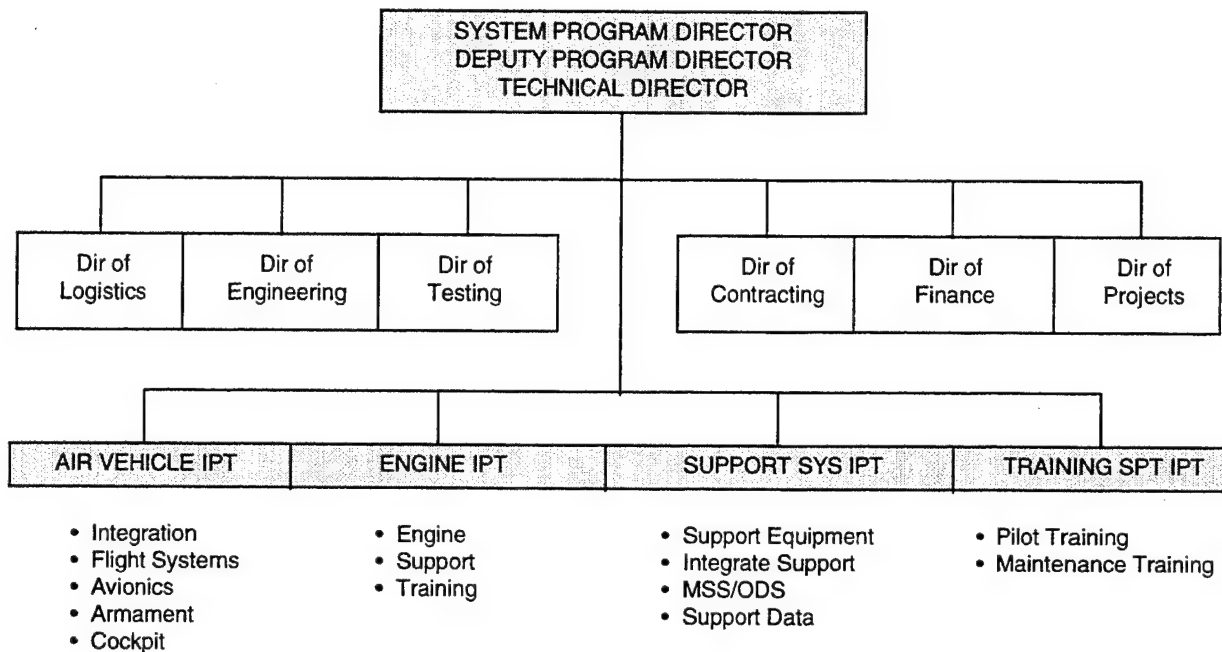
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## Acquisition, Streamlining and Lessons Learned Report for Crusader

philosophy, engineering and manufacturing development (EMD) execution, and air vehicle integrated product team (IPT) management. The chart below shows the F-22 IPT organizational structure.



The Team returned with data and information on how to best design the AFAS IPTs using the F-22 as a baseline. LTC Henry continued to collect data on other programs until late 1992. Once the research was completed, the analysis revealed that IPTs based on the Air Force's F-22 project organization was a distinct option for the AFAS IPTs. Shortly thereafter, LTC Henry briefed COL Napoliello and COL Geis (PM FARV) on the results of his efforts. Late in 1992, both Laboratory Command (LABCOM) and the Armament Research, Development and Engineering Center (ARDEC) were briefed and provided their support for the IPTs concept. This was followed by the Assistant Secretary of the Army, Research, Development and Acquisition [ASA(RDA)] Cypress Executive Session, where MG Ronald V. Hite, Deputy for Systems Management, ASA(RDA) approved the concept. In January 1993, LTG William H. Forster, Military Deputy to the ASA(RDA) was briefed and his endorsement was received for the IPTs. Following LTG Forster's briefing, elements of the Army Materiel Command (AMC) were briefed on the concept and, with MG Hite's assistance, AMC endorsed the IPTs concept.

### iv. RFP Development

Although the AFAS/FARV was to be developed as a single system, the RFP (Request for Proposal) was originally developed first for AFAS because it was a bigger project and because the program's managers had ARDEC's support and could easily obtain people to develop a team for AFAS RFP development. It was difficult to convince those in authority that both systems were part of a single system. One of the main reasons was that AFAS was a Field Artillery-managed project and FARV was an Ordnance Corps-managed project. Neither of these projects'



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management officials wanted to lose the equivalent of a command position - essential for consideration to become a General Officer. Another reason was that many civilians who had been working in the separate project offices were apprehensive that their jobs would be downgraded or eliminated by combining the two projects as one system. Even as the two projects emerged, it became evident that both projects had similar sub-systems - the main difference being that one system had a gun and the other system provided storage. Common sense dictated that similar components have common maintainability.

### B. FARV

#### i. *Project Manager (PM)*

Colonel James G. Voss (OD) was selected as the first FARV Project Manager from February through August 1992. Colonel John P. Geis (OD) succeeded COL Voss and continued through February 1994. As noted earlier, FARV was a separate project from AFAS with the exception of the common chassis.

#### ii. *FARV Development*

The FARV project is a continuation and expansion of Army technology base efforts to investigate the automating of tank and artillery resupply functions. It is structured to sufficiently demonstrate the maturity of FARV technologies, satisfy the Army and Office of Secretary of Defense (OSD)-approved MS I exit criteria, and reduce Government risk prior to entering the Development Phases I and II contract. The FARV project did not become a new start until early 1993 vice the AFAS new start in mid-1989.

Because of this, the FARV project lagged almost 18 months behind AFAS. Funding was not allocated by system but by projects (e.g., survivability, mobility). Because they were two separate projects, both had to compete at the ASM level for project funding. Much of the funding success of AFAS was because of the ASM reorganization to Field Artillery Systems (FAS), the high priority placed on AFAS, and the longevity at Picatinny of the AFAS personnel. In order to develop both systems concurrently, funds were reallocated within Project Element 63645 to begin systems requirements analysis and design activities for both AFAS and FARV.

#### iii. *AFAS/FARV Single System*

About a year prior (1989) to establishing the Project Executive Office Field Artillery Systems (PEO FAS), Mr. Dale G. Adams was approached by LTG William H. Forster, Military Deputy, ASA(RDA), who stated that the Vice and Chief believed that the AFAS/FARV programs should be placed under one PM and that Mr. Adams should examine how to achieve this merger. Mr. Adams directed his key staff to look at different scenarios and submit their ideas to him. Once it was announced that COL Napoliello was being transferred and that his replacement had not been named, Mr. Adams took the ideas and discussed them with MG Hite and MG Williams and drew an organization chart for the proposed organization. Mr. Adams then showed the new structure to LTG Forster who endorsed the concept. The common sense

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approach was to make COL Geis the new PM immediately since there would be continuity of contracts and programs with which COL Geis was familiar.

In February 1994, by direction of the Acting ASA(RDA), Mr. George E. Dausman, the management structure of the AFAS and FARV projects were merged with a single chartered Colonel Project Manager, at Picatinny Arsenal, NJ. COL John P. Geis (OD) was selected as the first AFAS/FARV PM until his departure to the Pentagon on 16 September 1994 as Executive Officer to the Army Acquisition Executive. COL William B. Sheaves III (FA), the AFAS/FARV Assistant Project Manager, succeeded COL Geis. The Project Manager executes materiel development and acquisition, with oversight and direction provided by the Program Executive Officer (PEO), Field Artillery Systems, also located at Picatinny Arsenal.

### C. Lessons Learned

LESSONS LEARNED - MANAGEMENT
<ul style="list-style-type: none"><li>• AFAS/FARV should have been one system with one Project Manager from the beginning. This would have provided earlier common development and acquisition streamlining, as well as cost effective staffing.</li><li>• This single system approach would have avoided the organizational issues/problems of combining two projects.</li></ul>



## 3. ACQUISITION APPROACH

### A. Restructuring

#### i. *ASM-Future Project*

The ASM- Future Project was presented to the OSD Conventional Systems Committee (CSC) in August 1992. This meeting resulted in the approval of the AFAS and FARV development project. The CSC also prioritized technology development efforts in the areas of firepower, resupply, survivability, and mobility. Systems integration efforts were discontinued and deferred to the Demonstration/Valuation (Dem/Val) phase. In addition, the CSC approved the restructuring of existing contracts, retaining only those activities approved in the review. The retained mobility system development efforts were refocused strictly on the needs of AFAS and FARV. The project focus is deliberately centered upon satisfying AFAS and FARV requirements. The CSC approved the restructured ASM project and the Under Secretary of Defense for Acquisition signed an Acquisition Decision Memorandum (ADM) on 16 September 1992, reaffirming Milestone 0 approval for AFAS and FARV. The ADM directed that the AFAS and FARV programs continue component level maturation and risk reduction efforts and return for a Milestone I decision review when OSD's exit criteria are met.

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### *ii. Procurement Objective*

The objective of this procurement is to design, fabricate, field, and sustain an AFAS/FARV System comprised of the advanced self-propelled 155mm howitzer and its companion automated resupply vehicle. These vehicles are required to operate as an integrated fire support system as well as being separately capable of accomplishing their individually unique missions. To optimize their combined operational effectiveness and minimize development, production and sustainment cost, commonality between them was an important system consideration. But this was based strictly on the AFAS and FARV requirements and the extent determined by performance and cost effectiveness.

### *iii. Single Developing Contractor*

The interoperability requirement of the vehicles in the operational environment, the desire to achieve commonality, and the need to maximize concurrent engineering, performance and affordability, necessitated an acquisition approach which capitalizes on this interdependence. Therefore, the acquisition strategy was founded using a single system contractor, for both AFAS and FARV, to reduce the Government's burden of system integration and development risk.

This strategy provides for a single contact, utilizing separate AFAS and FARV system performance specifications, awarded to a single prime contractor. AFAS technologies emerged from the Army laboratories and industry and, in 1989, these efforts and associated funding were consolidated under the PEO Armored Systems Modernization and continued in project management offices.

## **B. Lessons Learned**

LESSONS LEARNED - ACQUISITION APPROACH
<ul style="list-style-type: none"><li>• A single development contractor approach optimizes effectiveness and development of AFAS/FARV through systems commonality.</li><li>• The single developing contractor leverages all prior investments by the government (\$565M).</li><li>• The approach minimizes project costs by optimizing existing facilities and capabilities.</li><li>• The loosely worded Exit Criteria at MS 0 will increase risk in Phase 0-I.</li></ul>

## Additional Lessons Learned, Updating, and Notes for Crusader

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**4. ACQUISITION REFORM, THE ARMY'S "ROADSHOW," AND AFAS/FARV**

**A. Background**

In 1991, the Army acquisition community began to apply a number of reform initiatives aimed at improving the way we buy services and equipment. By September, 1993, the intensive "Roadshow" method of exposing Army Acquisition and procurement organizations to these initiatives had arrived at the third "plateau." Where Roadshow I provided initial thoughts and sought field feedback, Roadshow II included 15 principles for improving the acquisition process. The 15 points, by September, 1993, were expressed as follows:

- Use a multi-disciplined team approach to integrate acquisition product and process management.
- Reduce cycle times in all acquisition processes
- Facilitate rapid introduction of technology advancements.
- Develop acquisition strategies which set priorities, identify streamlined paths to early fielding and involve the user.
- Reduce the functional requirements in every aspect of an acquisition. Eliminate all that add little or no value.
- Aggregate requirements into fewer and longer term contracts.
- Base RFPs on product performance specifications. Remove barriers to dual-use technologies and simultaneous manufacturing.
- Increase the use of best value contracting.
- Integrate cost effective testing throughout the life-cycle by involving testers and evaluators early in the process.
- Make full use of international markets and technology.
- Use acquisition planning to manage the "right sizing" of the industrial base -- protect critical segments.
- Reduce operating and support costs throughout the life cycle.



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- Promote quality through customer focus, process review and continuous improvement.
- Institutionalize acquisition improvement principles as all levels. Train and operate within multi-disciplined teams.
- Use electronic media infrastructure to reduce cost and improve quality as it becomes available.

### **B. The Roadshow III Program**

Roadshow travelers met in their hotel the evening of 22 September 1993 to coordinate facilitation tasks. On 23 September Roadshow III commenced in ARDEC Headquarters' Auditorium. HQ AMC (Brown) provided a course overview, followed by DoD's (Sullivan) presentation of the Acquisition Principles. Presentations on Improving Acquisition Strategies (Griffin) and Partnering (Richards/DeFrieze) concluded the early morning sessions. HQ AMC's Max Westmoreland then presented the Templating Concept, Application, and foreshadowed the afternoon's Practical Exercise. After lunch, the Roadshow Team's facilitator supported six breakout groups. This process was continued through the morning of Friday, 24 September, when, at 1030 the results were reported out and discussed in general session. At noon the final presentation, Commodity Area Templating, was made by J. Brown and M. Westmoreland of HQ. AMC.

Having selected the AFAS/FARV and XM982 Extended Artillery Projectile as PEO/ARDEC's case study choices for major and commodity-type programs, the group determined that these candidates would be assessed in light of the Principles and Templates, then report out to the reassembled Roadshow III participants on 3 December, 1993. This provided the AFAS/FARV programs with an excellent "filter" to apply to their Acquisition Strategy, and was enthusiastically resourced and supported by the PMs.

### **C. Roadshow III AFAS/FARV Analysis/Results**

On 3 December, 1993, Tom Hartigan briefed the results of the Roadshow analysis to the participants. The following paragraphs summarize these findings, by category briefed:

#### *i. Outline*

Introduction (Team/AFAS/FARV), Acquisition Strategy, RFP Status, Template Analysis (selected), Application of Acquisition Principles, Team Findings, Summary.

#### *ii. Team Profile*

As indicated in the following table, the following personnel performed the Roadshow analysis:

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Team Member	Years Experience	Area of Expertise
Jim Gaida	32	Manufacturing/Producibility
Jeff Boyle	19	Procurement
Bob Parise	15	Legal
Burt Spiegel	32	ILS
Cliff Daly	38	System Engr./Mgt.
Dan Nathan	24	System Engr./Software
Tom Hartigan	8	RAM/QA
Daren Nielsen	5	Product Assurance
Rusty von Schwedler	25	Sys. Engr./Mfg./Prod./ILS
Nan Holder	5	Electrical Engineering
Lester Jee	20	MANPRINT/Human Engr.
Mark Oetken	8	System Engineering
Iris Edwards	5	System/Industrial Engr.
Tom Fitzgerald	18	Pgm. Mgt./Ammo Log.
Tom Lazenby	7	Cost Effectiveness Analysis
Phil Cardon	23	Log./Mobility
Walt Storrs	26	System Engr./Mobility
Carol Sitroon	12	Contract Management
Lee Mund	26	System Engr./Proj. Mgt.

These personnel were provided 2.5 days of AMC-sponsored training on the Acquisition Templates prior to commencing their analysis.

### *iii. Acquisition Strategy*

The briefer indicated, with Tank Automotive Command (TACOM) Notional Concept Diagrams, that this is the acquisition of a system, defined as AFAS and FARV. Top Level characteristics of the acquisition will be:

- Competitive Selection of a Single Prime Contractor
- Prime Responsible for the Total System Development
- A Performance Specification Contract Approach (the biggest change)
- An Integrated Product Development Concept
- Common Components and Software will be maximized
- Concept Exploration and Definition Technologies will be Infused
- Government furnished equipment (GFE) will be Minimized

For the Dem/Val Phase:

- The Prime will be from the US/Canada Industrial Base
- Cost Plus Award Fee Contract Planned

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- Six Year Dem/Val Phase
- Best Value Base for Contract Award, Including 1) Achievement of Required Performance (System-level, for both AFAS & FARV), 2) Realistic Cost, and, 3) Cumulative past Performance
- Capability for R&D, Prototyping, Manufacture and Support

EMD Phase will feature:

- Sole Source Award to the Dem/Val Contractor
- Scope to Include Low Rate Initial Production (LRIP)
- Competition in the Subcontractor and Vendor Base

The Integrated Product Development approach will be characterized by:

- A TQM/Concurrent Engineering Approach
- Multi-Disciplinary Teams with a Product Focus, and the Authority, Responsibility, and Resources to accomplish their work
- Implementation to Begin with the Contractor Proposal, to include an Integrated Master Plan, an Integrated Master Schedule, and Technical Performance Measures
- A Philosophy, as much as a Way of Doing Business, that provides an integrated framework for Concurrent Engineering, bringing the right people together, at the right time and place to make the right decisions

The RFP Schedule was briefed, informing the group that the RFP preparation was in the final stages, a Tiger Team had commenced review of the Solicitation Process and Schedule, and that their findings were being briefed to PEO ASM this date (3 December 93). Glen Caltabilotta, Chief of the ARDEC Management Branch provided the post-RFP release schedule, which was targeted to reduce Program Acquisition Lead Time (PALT) from a typical 315 days to 150 days in the case of Crusader.

Of the 22 prototype Acquisition Templates espoused by Roadshow III and described below, those highlighted in boldface below were briefed in detail:

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**ROADSHOW III TEMPLATES**

- |   |   |
|---|---|
| • <b>System Engineering</b>                         | • Part Control                          |
| • Engineering Data and Specifications               | • Electromagnetic Environmental Effects |
| • Configuration Management                          | • Special Support & Test Equipment      |
| • Life Cycle Software Engineering                   | • Integrated Support Planning           |
| • <b>Reliability, Availability, Maintainability</b> | • Logistics Support Analysis            |
| • Safety Engineering                                | • Technical Publications                |
| • Environmental Engineering                         | • Provisioning                          |
| • Packaging & Transportability Engr.                | • Maintenance Training                  |
| • Mfg. and Producibility Engineering                | • Program Management                    |
| • MANPRINT & Human Factors Engr.                    | • <b>Systems Test &amp; Evaluation</b>  |
| • Value Engineering                                 | • Quality Assurance                     |

**D. Template Comments**

General comments were that 1) The AFAS/FARV Acquisition Approach embraces the Roadshow template recommendations, 2) the Templates appeared to assume an EMD or latter phase, and 3) Periodic functional meetings are necessary, but can be reduced in magnitude and number.

*i. Template #1 Comments (Systems Engineering), Alternate Approach*

The features of the AFAS/FARV approach were briefed as follows

- Government CE Teams are used to prepare the integrated system performance spec and contract SOW.
- System performance specs are used instead of detailed product specs. Interface control requirements are included in the spec.
- The contractor is required to describe his SE process and all relevant previous experience in his RFP response. No System Engineering Master Plan is required. The Program is assessed at periodic integrated functional reviews.
- The contractor retains design responsibility throughout the contract. The Government does not "approve" design status at design reviews, but reviews the SE process.
- Design to Cost (DTC) considerations are integrated with design engineering efforts. No program plans are required.
- Functional reviews are integrated and scheduled concurrently with prime contractor management reviews.

In commenting on the details of the template for System Engineering, the AFAS/FARV team general concurred, noting, however, that 1) While the Army shares in approvals by the IPT



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approach, the government still must have the key PDR/CDR decision milestones, the verification point of vertical and horizontal integrations, and 2) Some important functional areas should have a focused review process to assure horizontal integration among several IPTs (e.g., Logistics, Testing, Safety).

ii. *Template #5, Reliability, Availability, Maintainability (RAM), Alternate Approach*

The features of the AFAS/FARV approach were briefed as follows:

- Tailor RAM program tasks to acquisition characteristics (e.g., commercial, non-development items (NDI), development, production, sole source, competitive).
- Require the contractor to describe the tasks needed to meet RAM requirements in response to the RFP. Do not require a RAM plan.
- Analyze, during past performance evaluation, the reliability test data on similar system/s manufactured by contractor to reduce testing on the system being procured.
- Hold the contractor responsible for meeting RAM requirements. Do not approve plans and reports or hold separate RAM reviews.
- Make RAM demonstration an option. If the contractor has a history of exceeding the planned growth during development, a RAM demonstration should not normally be required.
- Include RAM status in periodic integrated functional reviews.

In commenting on the template detail for this template, the team departed from the template recommendations in the following respects:

- A newstart program that uses state-of-the-art technology like AFAS/FARV cannot evaluate RAM based on past performance. New equipment must be proven reliable through testing, since much of the content will be used in its first application.
- A "test-fix-test" approach, coupled with a rigorous FRACAS program would be another way to reduce testing. Getting to the root of the problems and eliminating failure modes will expedite the inherent reliability growth of the system and reduce the need for RAM demonstrations in later phases of development.
- Rather than reducing testing during Dem/Val, we should be designing and testing as effectively as possible to reduce testing and generate savings downstream.
- The Government should reserve the right to comment on RAM reports.

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- Although the IPT process will minimize the need for RAM Reviews, they will still be required for horizontal integration. Certain RAM functions must be conducted at a system level (e.g., development of RAM requirements, preparation for assessment of test data, scoring conferences).
- Even considering the predictable objections of Operational Test and Evaluation Command (OPTEC) and AMSAA, and the negative risk management implications, to forgo RAM demonstration on a newstart program the magnitude of AFAS/FARV would be ill-considered.
- Under Design Reference Mission Profile conditions, RAM specification requirements MUST be validated by TEST prior to Milestone III. RAM testing can be combined with other user and performance test to successfully validate RAM requirements, but this data must be carefully considered and collected in order to eliminate the need for a specific RAM Demonstration test. We recommend maximizing Subsystem / Component testing as a means to cut down on the system RAM demonstrations. This approach is much less costly and allows for faster fix implementation.

### *iii. Template #21, Systems Test & Evaluation, Alternate Approach*

This template was summarized by the AFAS/FARV team as follows:

- Use continuous evaluation to integrate and reduce testing.
- Involve the Government development tester and evaluator in the preparation of the acquisition strategy and on the CE team.
- Utilize simulation in development to combine and reduce testing.
- Use Statistical Process Control (SPC) to reduce in-process inspections and tests.
- Make use of available test facilities rather than construct new ones.
- Accomplish test integration within the boundaries of the periodic integrated functional reviews.

The team's comments on this template demurred from the model in the following areas:

- A valid concern (in involving testers and evaluators early, per the template) is in maintaining a consistent base of program experienced personnel--especially in organizations which are primarily staffed with military.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

- Simulation is useful as an early diagnostic during Dem/Val for certain requirements validation, but not as a substitute for validating most performance requirements. There is also challenge in convincing the Test and Evaluation (T&E) community to accept simulation to reduce testing.
- The template-recommended use of SPC (to reduce in-process inspection and tests) is more applicable to subsystem/component T&E. This element is better located in the QA template.
- The team did not concur with the template recommendation that test integration be accomplished within the boundaries of the periodic integrated functional reviews, asserting that a program cannot cover the kind of detail necessary for planning and integrating system testing on these occasions. If every functional area went into necessary detail on their issues, the meetings would last 4-5 days. They also noted that functional test meetings are necessary to assure cross fertilization and dissemination of lessons learned between IPTs.

The detailed handout provided attendees by team-members included a thorough set of concurrences, demurrals, and companion recommendations. Some of those comments and recommendations, keyed to the associated templates, are noted below:

TEMPLATE # /FUNCTIONAL AREA	TEMPLATE ASSERTION	AFAS/FARV TEAM COMMENT
#2 Engineering Data & Specs	<ol style="list-style-type: none"> <li>1. Performance specs are required to the lowest WBS selected for breakout ... breakout decision is integrated as part of the design process.</li> <li>2. Commercial dwgs. to the max possible.</li> <li>3. Contractor maintains the Technical Data Package (TDP) for life of the contract.</li> </ol>	<ol style="list-style-type: none"> <li>1. Concur, address in EMD negotiation; recommend entering mechanism in Dem/Val to allow Army evaluation of breakout potential.</li> <li>2. Concur, but for new drawings Govt. format is preferred (we expect a major contractor to have capability); team has concern with proprietary data and assuring Army has negotiated all rights.</li> <li>3. Concur.</li> </ol>
#3 Configuration Mgt.	<ol style="list-style-type: none"> <li>1. Prime contractor describes CM system in RFP response. No CM Plan.</li> <li>2. Interchangeability and interoperability criteria clearly spelled out as contractual requirements controlled by Government.</li> </ol>	<ol style="list-style-type: none"> <li>1. Concur, enter CM into the Integrated Master Plan (IMP) as reduced size plan.</li> <li>2. Concur, but team realized NATO type standardization may change as the contractor continues.</li> </ol>
#4 Life Cycle S/W Engr.	<ol style="list-style-type: none"> <li>1. Use commercial standards. for s/w development management tasks and processes to max.</li> </ol>	<ol style="list-style-type: none"> <li>1. Concur, good examples in RFP and provide definition of what management. and processes are used in R&amp;D &amp; how corrective actions are executed; proposal also explain how commercial practices can be applied to AFAS/FARV.</li> </ol>

**Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

TEMPLATE # /FUNCTIONAL AREA	TEMPLATE ASSERTION	AFAS/FARV TEAM COMMENT
	<ol style="list-style-type: none"> <li>2. Tailor application of MIL-STD-2167A to min. essential requirements consistent w/complexity.</li> <li>3. Contractor is required to perform s/w verification and QA functions. No Govt. IV&amp;V of contractor s/w testing. No MIL-STD-2168 requirement.</li> </ol>	<ol style="list-style-type: none"> <li>2. Concur, require a single document as the interface/control spec; assure sub contractor access to electronic library.</li> <li>3. Concur, using IPT oversight and CE to assure success.</li> </ol>
#7 Environmental Engr.	Specific environmental requirements are in system performance spec, including methods of determining compliance.	Concur, but in RFP, not the spec.
#9 Mfg. and Producibility	<ol style="list-style-type: none"> <li>1. Integrate mfg. and prod. design considerations during development through CE concepts.</li> <li>2. Do not require Producibility Engineering Planning or Mfg. program plans.</li> </ol>	<ol style="list-style-type: none"> <li>1. Concur, activity must be accomplished if a 3-yr. EMD phase is completed as desired.</li> <li>2. Concur, activities must be included in the contractor IMP.</li> </ol>
#1 Value Engineering	No VE Master Plans; standard VE clause in prime contracts	Not applicable during Dem/Val.
#15 Integrated Log Planning	<ol style="list-style-type: none"> <li>1. Require contractor to describe past performance; tailor requirements. for plans, reviews and reports to contractor's capability.</li> <li>2. Minimize separate functional planning conferences by including progress reporting in periodic integrated functional reviews.</li> </ol>	<ol style="list-style-type: none"> <li>1. Concur, giving consideration to exercising this intent as part of discussions and the best and final offer (BAFO) process.</li> <li>2. Agree in principle, but following important steps must be acknowledged: <ol style="list-style-type: none"> <li>a. Appoint an Integrated Logistics Support Manager (ILSM).</li> <li>b. Installation Supply Point (ISP), or intent, should be part of IMP.</li> <li>c. High level Integrated Logistics Support (ILS) mtgs./reviews part of system periodic reviews; however, joint Integrated Logistics Support Management Teams (ILSMTs), as required, will be fallback from Integrated Product Development (IPD) teams to coordinate. and review (horizontal integration) the more detailed ILS efforts.</li> <li>d. Give credible weight to log/maintenance influence in development process.</li> <li>e. Prime contractor will control subs.</li> </ol> </li> </ol>



**Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

TEMPLATE # /FUNCTIONAL AREA	TEMPLATE ASSERTION	AFAS/FARV TEAM COMMENT
		f. Intent of DoD 500.1 and .2 and MIL STD-13881A & 2B will receive optimum consideration...not to the letter, but to comply with intent. NOTE: similar comments apply to template #16, Logistics Support analysis.
#17 Tech Pubs	Use COTS manuals, joint contractor/Govt. validation, and minimize guidance conferences & reviews	Agree in principle, but: Commercial manuals should be used for maintenance, and test activities, except for final evaluations, e.g., Initial Operation Test & Evaluation (IOT&E). Provide for on-going review of manuals in joint forum. No contractor reproduction of manuals -- the Govt. should strive to ID the most economical method, enhanced by delivery of the pubs in magnetic format.
#20 Program Management	<ol style="list-style-type: none"> <li>Govt. degree of control based on overall contractor mgt. capabilities through past performance. No duplication of Mgt. information from Govt. auditors and contract administrators.</li> <li>Government CE teams conduct integrated functional reviews as a body - no separate functional reviews.</li> </ol>	<ol style="list-style-type: none"> <li>Concur.</li> <li>Disagree with no separate functional reviews. Agree with minimizing through the IPT/CE process, but assert the necessity to assure horizontal communications between/among IPTs, and to coordinate system requirements such as test schedules and assets and RAM allocations.</li> </ol>
#22 Quality Assurance	<ol style="list-style-type: none"> <li>Require no Program Plan; have contractor describe approach in RFP response.</li> <li>(Template recommends) relief from MIL-Q &amp; I constraints.</li> </ol>	<ol style="list-style-type: none"> <li>Agree, but detailed description should be defined in the IMP as a means of ensuring product conformance to specified requirements. Caution: Should proposals be inadequate, there is little recourse but for Govt. to define QA system and monitor compliance.</li> <li>Team recommends ISO 9000, either mandated, or used as the alternative standard by which the Govt. assures quality.</li> </ol>

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**E. Lessons Learned**

**LESSONS LEARNED - ROADSHOW**

- For ARDEC, both its largest program, AFAS/FARV, and one of its smallest, the XM982 Extended Range Artillery Projectile, were "guinea pigs," for Roadshow III, successfully applying the templates in a common sense manner, to achieve review of programs in light of streamlined acquisition initiatives.
- For the Crusader program, already exploring streamlining, Roadshow III's templates were addressed with substantial resources and analysis, to yield the best acquisition approach. Validation was provided during the follow-up Roadshow III visit, as T. Hartigan briefed out the resultant to the Army's Roadshow experts/proponents, as summarized in the preceding paragraphs.
- As indicated above, the Roadshow Templates provide a valuable set of guidelines for examining an Acquisition Strategy and an RFP, but only as guidelines, since program differences will mandate departures from the prescribed sets of rationale.
- Roadshow was a catalyst for AFAS to have its "stuff" together.
- Roadshow made the Acquisition leadership understand what acquisition reform was all about and carried the message through the DA staff.
- The biggest impact was the #3 Template mandated for all contracts.
- PM wants to waive the templates for small contracts because of the bureaucracy involved.

**5. STREAMLINING**

**A. RFP Release and Approach**

*i. RFP Release*

Several actions were planned to help streamline the AFAS/FARV projects. A key contracting action was the release of the RFP (18 July 1994) prior to the Milestone I decision, normally a streamlining option for Milestone II. The 16 September 1992 ADM provided for the formal release of the Dem/Val (now Development Phases I and II) solicitation prior to Milestone I, contingent upon OSD's review and approval of the Acquisition Strategy Report and RFP. See page I-51 for OSD's comments on the RFP. This allowed the project to save contract lead time and gain a head start on the System Development phases.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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### *ii. Army Lead Program (ALP)*

On 16 March 1994, LTG William H. Forster, the Military Deputy to the Assistant Secretary of the Army for Research, Development and Acquisition nominated the AFAS/FARV project as one of four Army programs to be designated an ALP for acquisition reform. The purpose of the ALP was to identify programs with innovative acquisition approaches, identify required regulatory waivers needed to execute the program's streamlining innovations, and allow the project to reap the associated schedule and cost benefits. Designation of AFAS/FARV as an ALP was contingent upon approval of the Defense Acquisition Executive.

### *iii. Approach*

The AFAS/FARV project will reflect a streamlined acquisition approach that is intended to reduce the time necessary to achieve First Unit Equipped (FUE) by 12 months from previous project plans. The project will include a single development cycle from Milestone I to Milestone III with a Defense Acquisition Executive In-Process Review (IPR) replacing the traditional Milestone II. This approach will leverage DoD acquisition reform initiatives for tailored milestone documentation and reviews. The Army intends to provide sufficient detailed documentation addressing all statutory requirements for entering Phase III (EMD) without the formality imposed by DoD 5000.2M and the formal Defense Acquisition Board (DAB) process. The single development cycle is structured into three phases. The traditional Demonstration and Validation project phase is replaced by an initial Simulation and Component Maturation phase (Phase I) and a Prototype Fabrication and Demonstration phase (Phase II). The Engineering and Manufacturing Development (EMD) phase is replaced by a Full System Development and Pre-production phase (Phase III). Activities traditionally associated with Dem/Val and EMD will not be deleted, but will be restructured and tailored to meet the specific needs of the AFAS and FARV project.

## **B. Integrated Product Development**

### *i. IPD Approach*

The Army is using an IPD approach in this acquisition. IPD integrates the tenets of concurrent engineering, total quality management, project management and financial management, and clear accountability in design, contracting and personnel management. The IPD approach employs performance- and event-oriented acquisition criteria and a contractor-developed Scope of Work to give the contractor maximum latitude to employ its unique capabilities in planning and organizing the project presented in its proposal. The heart of the approach is the establishment of complementary contractor and Government Integrated Product Teams (IPTs) with representation from appropriate disciplines in a true concurrent engineering environment. These teams are given responsibility for developing discrete system elements within allocated cost, schedule, and performance requirements.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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### *ii. Objective*

The Project Manager integrates the work of the IPTs and makes decisions on major cost and performance trade-offs to meet user requirements. The objective is to establish open communication between the contractor and the Government, and among development teams, so that the total effort can be optimally managed in the cost-type contract environment. The Project Manager includes the User as part of the management team to review any potential requirement/performance trade-off and assure the adherence of the AFAS/FARV system to the approved operational requirements document. The IPD approach commences with development and release of an RFP based on a system performance specification. The Government communicates to the contractor what is to be done, and the contractor balances performance, schedule, and cost with structured guidance to determine how to meet the performance specification.

### *iii. Strategy*

The AFAS/FARV contracting strategy requires that the prime contractor develop the contract Scope of Work based on guidance provided in the RFP. The contractor is afforded maximum flexibility in formulating his proposal. The contractor submits in its proposal an Integrated Master Plan (IMP), an event-oriented baseline containing key project events, and significant accomplishments and success criteria in the form of Technical Performance Measures (TPMs). Both the IMP and TPMs are tied to the contractor's Cost/Schedule Control System Criteria (C/SCSC).

### *iv. Schedule*

The project schedule is established, monitored, and adjusted through the use of an Integrated Master Schedule (IMS). Only a minimum number of key and essential dates are placed on contract. Technical growth is planned and monitored using TPMs and recurring data items, which establish the minimum performance thresholds, performance target values, and planned growth curves. The IMP, IMS, and TPMs are used by the Government to measure the contractor's performance and are the basis for the award fee decisions. In this approach the contractor commits to an executable project which balances performance, schedule, and cost, and is based on structured, disciplined, and clear guidance. The contractor manages according to its plan; the Government evaluates and rewards performance. This approach is consistent with the new Acquisition Streamlining proposals of the Under Secretary of Defense for Acquisition and Technology.

### *v. Concurrent Engineering*

An additional streamlining initiative is Concurrent Engineering and User Testing during Phase III. First cost and schedule reductions will be realized for packing, shipping, and unpacking duplicative data acquisition, the reduction of resources through learning curves and training of personnel, and maximizing existing capabilities at Army proving grounds by performing both tests in the same location.



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Integrated Product Development Teams have emerged as a useful method of assuring that a high degree of interdisciplinary talent and thought are brought to bear early in the design process. This is a concurrent engineering-derived development which has gained ascendancy from origins in the USAF F-22 program, and is a favored method taught by the Defense Systems Management College. Army experience in earlier combat systems programs has seen TDPs emerge for Logistics and Life Cycle Support that were developed prior to production, and could have benefited from common packaging, parts, and other devices and methodologies that are learned during the early stages of execution of a Production TDP. While the Computer Aided Acquisition and Logistics Support (CALS) program has evolved beyond its origins and original intent, that of a "computer-aided logistics system," the culture of logistics and logisticians standing separate and apart from "those who really build them," is one striking example of the need for concurrent engineering approaches from the onset of a new system development.

Another set of benefits beyond those of integrating logistics and producibility into a concurrent engineering/Integrated Product Development (or Design) Team is exemplified by the Parable of the Cruise Control, a story told in the US automotive industry: When car designs were nearing completion, the Chiefs of Engines, Transmissions, and other major systems were called together in a final design review. The Engineer in charge pronounced all to be in order, but noted the absence of a Cruise Control System. "Where is it?," questioned the Chief Engineer. "Not part of the Engine," responded the Chief of Engines. "Not ours," noted the Chief of Transmissions, who was echoed by the other Chief and minions. So a junior engineer, just out of a small mid-western university, was tasked to design the Cruise Control over one long holiday weekend, and his/her design has been repeated for decades. The message is one of ownership, responsibility, and synergy, with involvement of all the experts from the initial stages of design.

As the AFAS/FARV Integrated Product Development Teams mature, and both government and industry representatives are assured of ownership, are clear on responsibility (for both cost and design targets and tradeoffs), and develop the necessary synergy, there should be lower risk of oversights and lower costs in testing in the usually painful process of integration because testers become part of the teams.

The office of the Project Manager stays abreast of insights and lessons learned through the DoD Concurrent Engineering Forum. The Forum meets quarterly, with responsibility for hosting meetings which are rotated among OSD and the Services. The Forum serves as an educational vehicle to spread the understanding of concurrent engineering principles and to discuss both current and pending DoD/Service/Agency policy.

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**NOTES**

### vi. *Distributed Interactive Simulation*

The PM intends to employ Distributed Interactive Simulation (DIS) simulation facilities and virtual prototyping as an integral part of the AFAS and FARV development project. Virtual prototyping and simulation offers the promise of more efficient engineering, leading to earlier prototype delivery in Phase III and the possible reduction of test vehicles and test cycle time that will be required for testing and concurrent crew training.

### vii. *Early User Test using Models and Simulation*

DIS allows testing AFAS and FARV units in Early User Test (EUT) during Phase II, through the use of AFAS and FARV crew stations to supplement prototypes. Costs and time will be saved by leveraging use of these simulators to perform pilot training on a virtual battlefield replicating the eventual operational tests with live vehicles. Substantive elements of the enemy force and Blue Reconnaissance, Surveillance and Target Acquisition (RSTA) assets can be simulated on the virtual battlefield for the actual AFAS/FARV Initial Operational Test (IOT), providing additional operational test savings. The objective strategy in the use of simulations is to develop a single, universal mathematical model that will leverage data for use during system development, test and evaluation, production, and training. The Government will retain software rights to all pertinent models and simulations. Also, computer resource development metrics will be collected and evaluated to monitor management processes.

### viii. *AFAS/FARV Simulation Activities*

AFAS/FARV simulation planning and activities reflect the economies of the merger of two complete vehicles under one developer/Program Manager. Based upon requirements analysis current to 9/95, the Self Propelled Howitzer (SPH) and the ReSupply Vehicle (RSV) are 66% common, 24% SPH unique, and 10% RSV unique. This commonality forms a basis for a broad spectrum of simulation commonality, as well as commonality in the development of objective products.

In achieving a significant technological leap forward, it is worthy of note to consider some of the areas which represent these advances, then to progress into the simulation-friendly aspects of the development. Consider the following new-technology or generational improvements from the following:

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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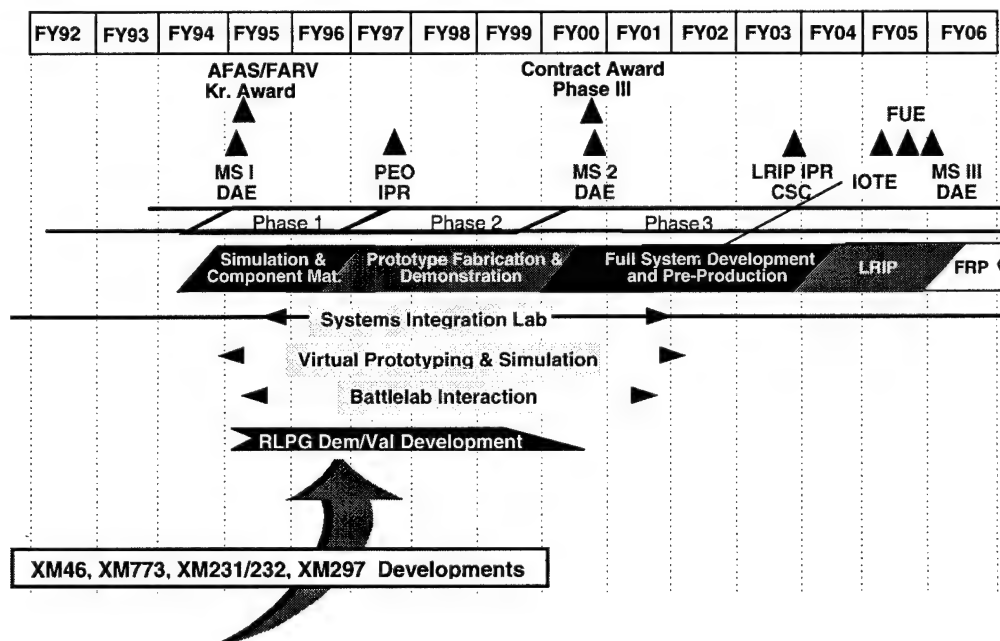
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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

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|--|---|---|
| <ul style="list-style-type: none"> <li>• Regenerative Liquid Propellant Gun</li> <li>• Enhanced Survivability</li> <li>• Improved Navigation</li> <li>• Integrated Defense System</li> <li>• Improved Track</li> <li>• Open, Modular, Redundant Vehicle Electronics</li> </ul> | <ul style="list-style-type: none"> <li>• Large Caliber Automated Ammo Handling &amp; Mgt. System</li> <li>• Improved NBC Protection</li> <li>• Advanced Fire Control</li> <li>• Advanced Automated Crew Stations</li> <li>• Enhanced Diesel Power Train</li> <li>• Design for Production</li> </ul> | <ul style="list-style-type: none"> <li>• Automated, Protected Ammo Resupply</li> <li>• Embedded Training</li> <li>• Designed-in Signature Management</li> <li>• Enhanced Communications &amp; Identification]</li> <li>• Advanced Digital Design</li> <li>• External Hydropneumatic Suspension</li> </ul> |
|--|---|---|

The AFAS/FARV Program Schedule identifies Simulation and Component Maturation occurring through FY97, with virtual Prototyping and Simulation, interaction with Battlelabs, and Systems Integration Lab activities occurring simultaneously throughout the Dem/Val (Phase I/II) period, as shown in the attached Program Schedule extract:



Key Dem/Val Products include the following:

System Level Integration Demonstrators (SLIDs) for each vehicle, to include an automotive "Iron Rig" for installation, assembly, test, & checkout, development of an electronic

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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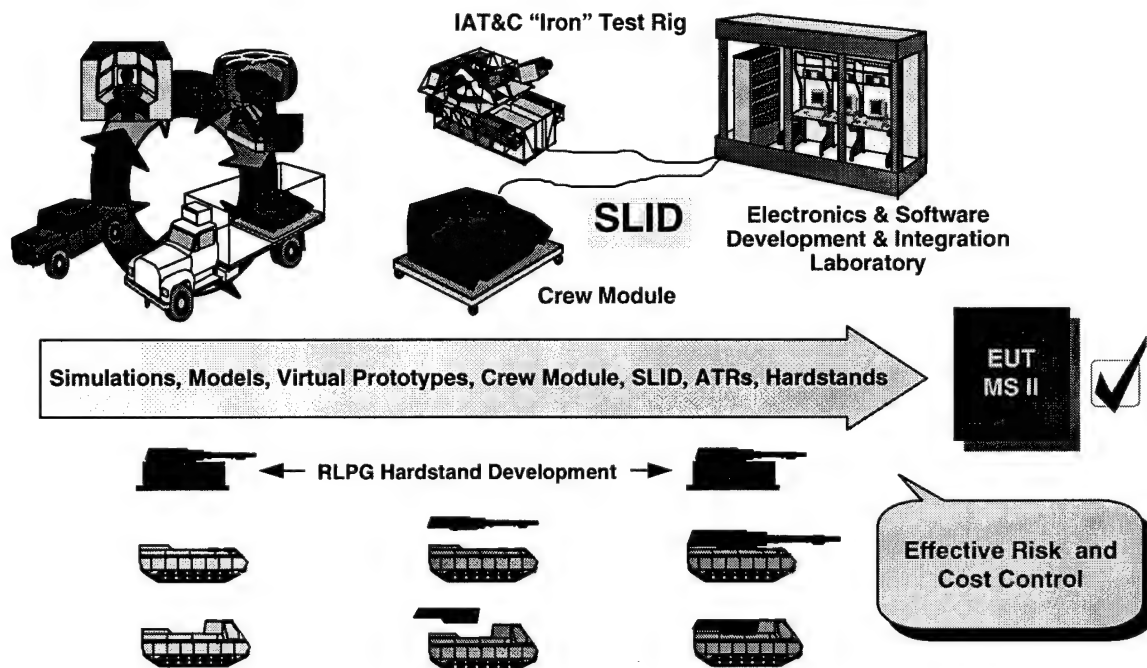
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## Acquisition, Streamlining and Lessons Learned Report for Crusader

and software development and integration lab, and a crew module demonstrator. In addition, two Automotive Test Rigs (ATR-1 SPH, ATR-2 RSV), and , in Pittsfield, MA, RLPG Hardstands are planned. The RLPG4 Hardstand will demonstrate Range, Muzzle Velocity Control & Repeatability, while the Prototype Cannon will demonstrate weaponization and Muzzle Velocity Control.

Crew Station Simulators and Surrogate Vehicles are planned for User feedback and evaluations. Both System and Factory Virtual Prototypes round out the key products for this program phase. The figure below illustrates these developments as they lead toward Early User Test (EUT) and achieving Milestone II approval:



At the system simulation level, the AFAS/FARV approach provides for the interplay among and between Soldier/Soldier Machine Interface (SMI) Models, Electronics and Software System Models, and Solid Models, with the nexus describing a system-level predictive model output. This output would capture system design characteristics and form the basis for all succeeding development. The linkage between simulation and integrated product development is illustrated in the following graphic, which is tied numerically to the present-date work breakdown structure and reflects the breadth of integrated product team participation in the effort:



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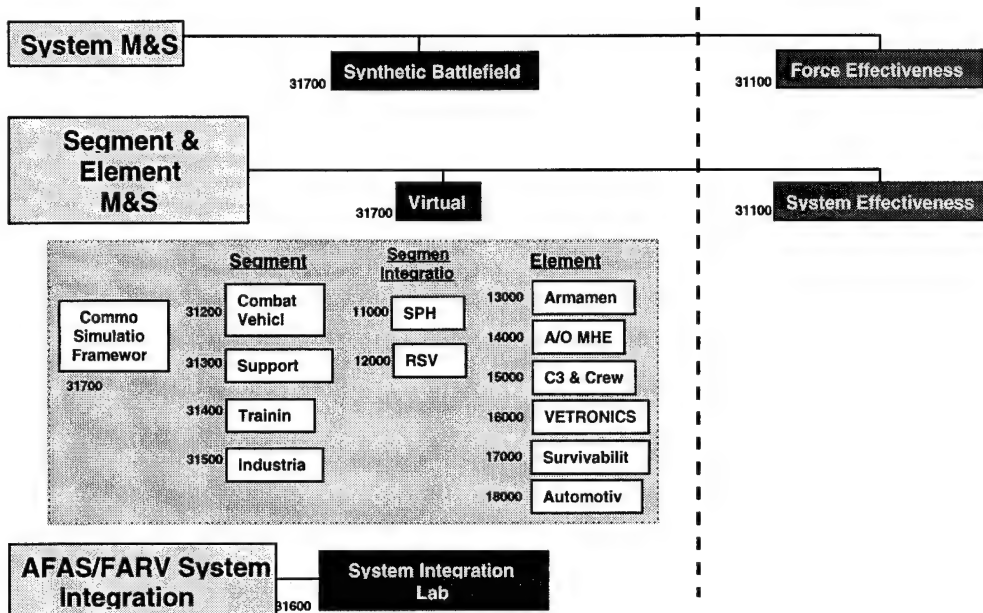
**Additional Lessons Learned, Updating, and Notes for Crusader**

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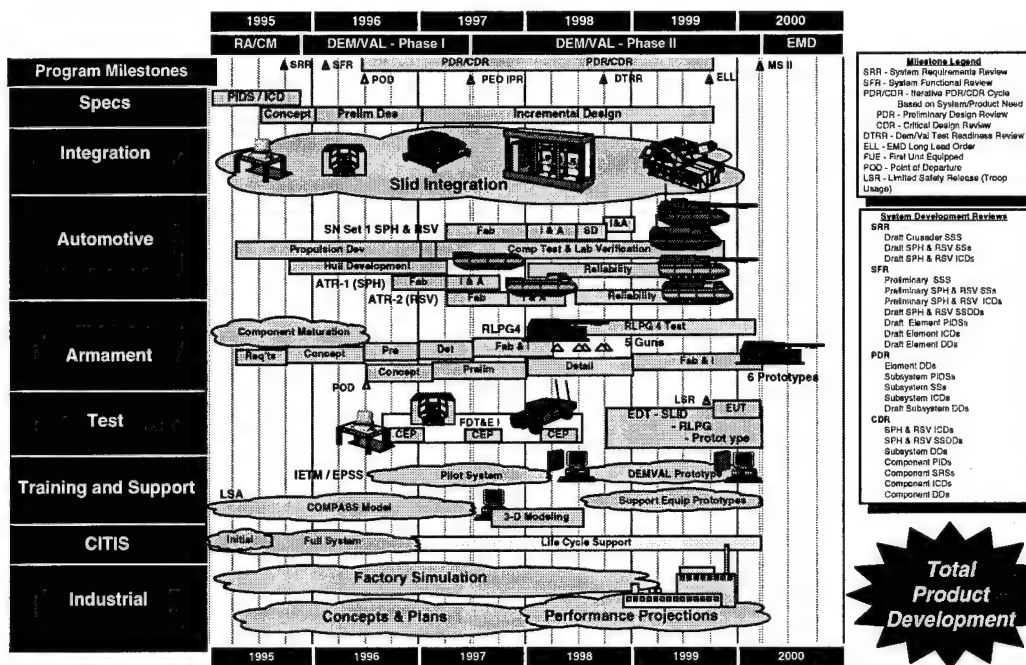
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As simulation activities roll up into the System Development Plan, the following timeline are presently projected:



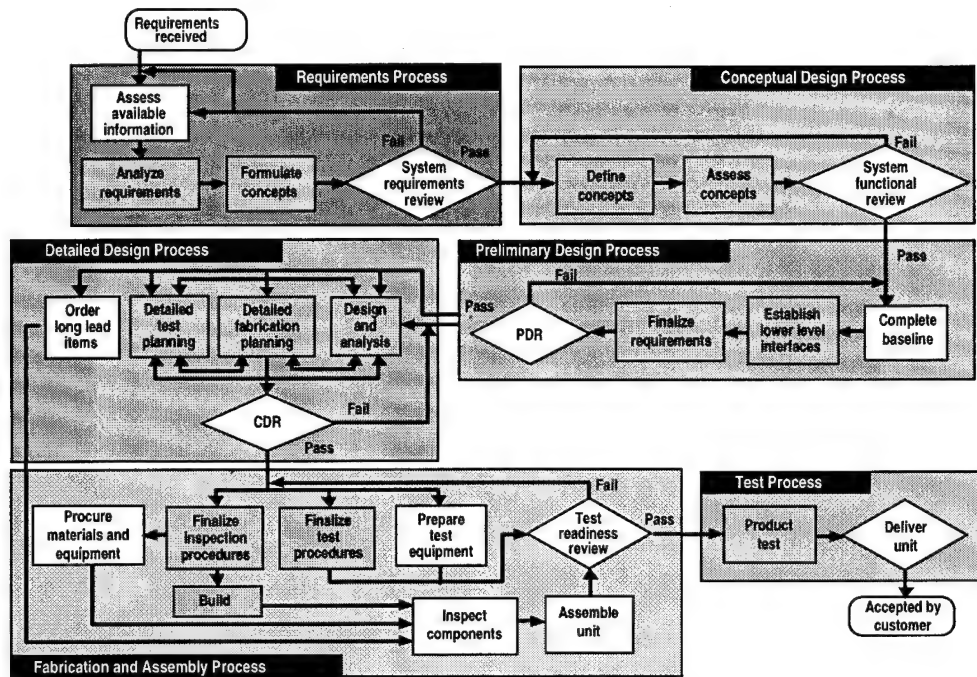
Operative flowcharts that describe the relationships between and among simulation and system engineering are providing a baseline for present work:

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Planned simulation activities, keyed to phases of development are summarized in the following table:

DEVELOPMENT PHASE	SIMULATION ACTIVITIES
Requirements Analysis	System Level Representation of Object Architecture Element Level Representation of Object Architecture Definition of Common Simulation Framework
Concept Formulation	Develop initial models of product items-low fidelity/high level functionality
Preliminary Design	Iterative Refinement Process to add fidelity First Generation Virtual Prototypes (VPs) support PDR
Detailed Design	Continue Iterative Process, adding fidelity of model & simulation 2nd Generation VPs support detail design, & CDR- man in the loop
Fabrication & Assembly	Replace Models with target H/W and S/W 3rd Generation Vps support EUT with SMI
Test	Evaluate in the System Integration Laboratory (SIL) SLID supports MS II exit criteria

To illustrate iterative system development in an rapid prototyping Mod/Sim environment, the AFAS/FARV concept is as shown below:

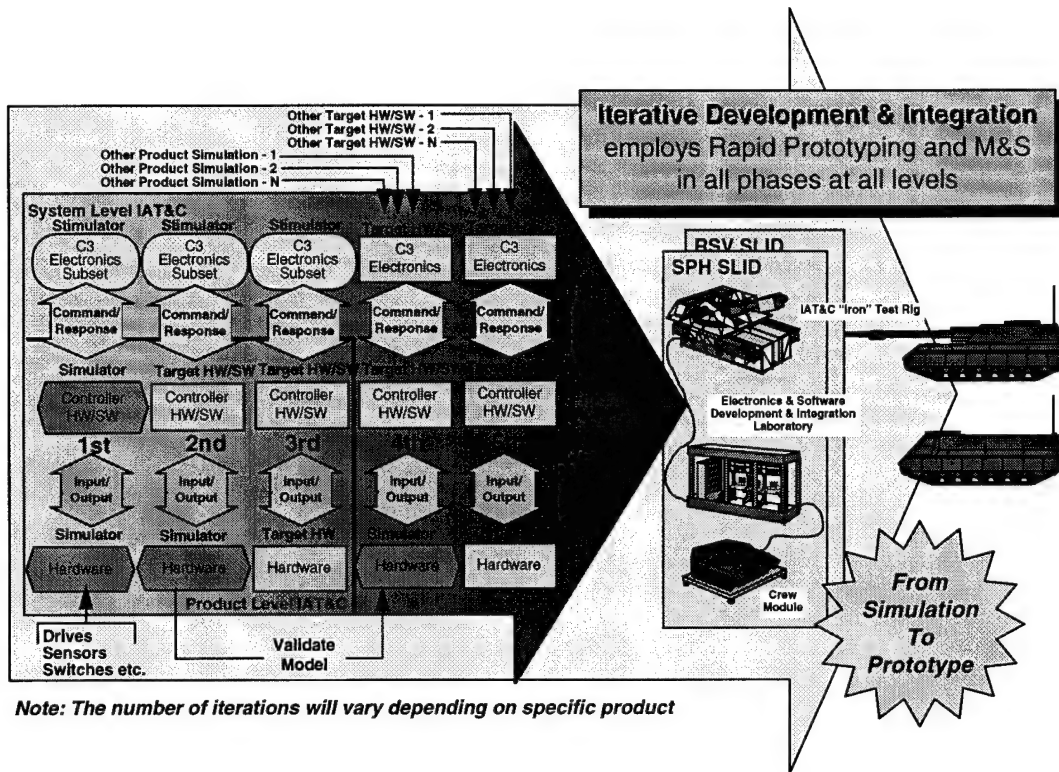
**Additional Lessons Learned, Updating, and Notes for Crusader**

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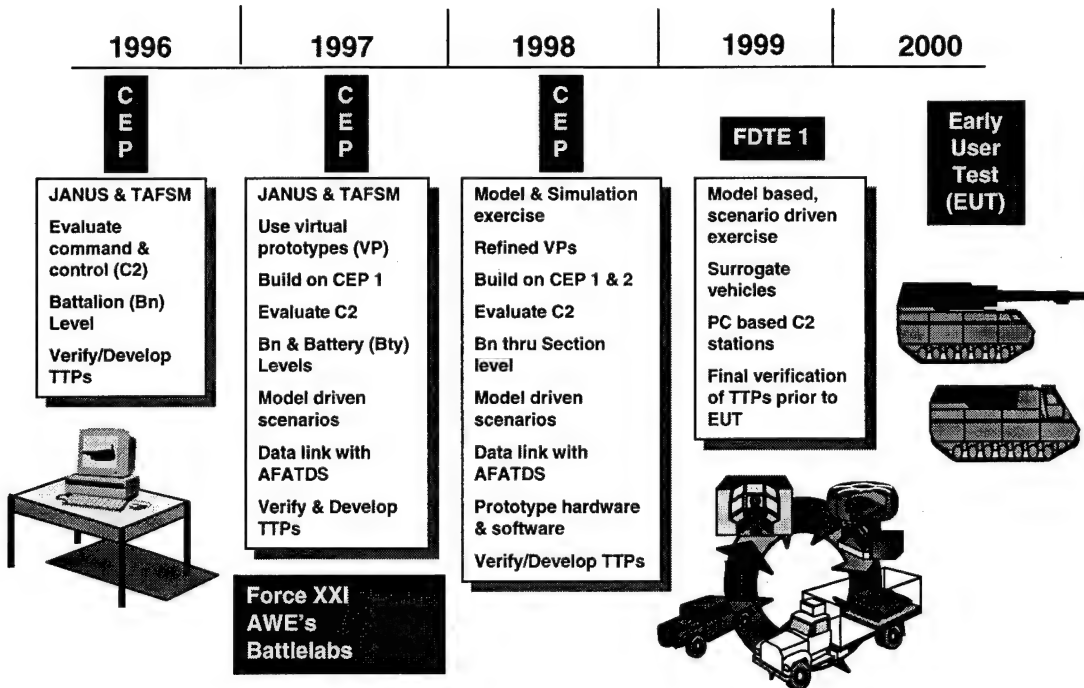
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**NOTES**

# Acquisition, Streamlining and Lessons Learned Report for Crusader



To insure early interface with the user and the warfighters, AFAS/FARV will continue to pursue initiatives to assure force integration. This figure projects these initiatives, by Phase I/II year:



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Simulation is a cornerstone of the system development plan for AFAS/FARV to contain acquisition cost and manage risk. Virtual prototyping is anticipated to minimize the numbers of hardware build iterations; simulation is being used to layout manufacturing facilities and to support preliminary assessments of the production process. A key challenge is to integrate the iterative system development process into the program schedule in an Integrated Product Team environment. Early user and warfighter familiarity and valuable feedback will occur as PM AFAS/FARV continues to invest heavily in force integration and the battlelabs and Army Warfighting Experiments.

### *ix. Regulatory Relief*

DoDI 5000.2, Part 3 outlines the purpose and function for each milestone. DoDI 5000.2, Part 2 states that "the number of phases and decision points must be tailored to meet the specific needs of the individual programs." In concert with the intent of DoDI 5000.2, authority was requested to proceed from Milestone I through three tailored phases of engineering development to Milestone III including initiating of Low Rate Initial Production (LRIP). The Milestone II will be replaced by a Defense Acquisition Executive (DAE) In Process Review (IPR) which will address only key technical, schedule, and cost information. This streamlining process will save the program time and money by tailoring the milestone process and presenting the information to the decision makers in a more concise manner. The consolidation of plans and reviews will tailor the need for many of the over 40 required and supporting Milestone II Documents. In addition, this tailored strategy will save valuable time for many key DA and DoD executives and their staffs by reducing the need for the series of pre-briefings and pre-milestone events leading up to the Milestone II. This includes tailoring of the DA Conventional and Strategic Systems Committee Review, the Pre-ASARC, and the ASARC and at the DoD level the Conventional Systems Committee Review and the DAB. From the Project Managers viewpoint preparation and execution of a Milestone takes approximately one year. During that year a major portion of the PM's personal resources are typically occupied by the milestone preparation effort.

DoDI 5000.2, Part 4, Section C, requires "the MDA will approve the final list of critical system characteristics as part of the Milestone II decision." It was requested that this requirement be deferred since the AFAS/FARV Program streamlined approach does not include a formal Milestone II. The Critical Systems Characteristics will be presented as a significant part of the DAE IPR. The AFAS/FARV program is technically more mature going into Milestone I than most systems. Critical Systems Characteristics presented at Milestone I should be representative of what would be presented at Milestone II.

AFAS/FARV proposes a single, expanded Integrated Logistics Support Plan (ILSP). The ILSP already addresses all of the essential parts of these documents and the incorporation of this solution will serve several purposes. First, it will create a single, support planning document which will decrease the opportunity for contradictory guidance which can stem from separate support plans. Second, it will decrease the amount of TDY required for separate working group meetings, leaving personnel with multiple memberships more available direct labor time. Third, the consolidation of documents will save the program time and money by eliminating the resources required for preparation of many vs. one support plan. Lastly, and perhaps most



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important, is the opportunity for the separate support disciplines to "cross-pollinate" and develop a support plan that will truly be "integrated." It was requested that the above regulatory requirements be waived in lieu of one consolidated ILSP.

A Health Hazard Assessment (HHA) will be conducted continuously as part of the Systems Engineering process and implemented through the actions of the Government/industry Integrated Product Development Teams. The AFAS/FARV PMO has established a requirement for the prime contractor to conduct an HHA prior to Milestone III. Although the prime contractor has the requirement for an HHA, it will be conducted by the Integrated Product Development Team and not solely by the contractor. It was requested that since the AFAS/FARV strategy does not include a formal Milestone II, and a team effort assessment will be conducted prior to Milestone III, the requirement for a Government HHA be waived in lieu of a contractor HHA.

The AFAS/FARV PMO has established a requirement for a prime contractor-prepared the System Safety Management Plan (SSMP) prior to Milestone III. Although the prime contractor has the requirement for SSMP, it will be conducted by the Integrated Product Development Team and not solely by the contractor. Updates and revisions to the SSMP will be conducted continuously as required as part of the Systems Engineering process and implemented through the actions of the Government/industry Integrated Product Development Teams. It was requested that since the AFAS/FARV strategy does not include a formal Milestone II, and a team effort preparation of the SSMP will be conducted prior to Milestone III, the requirement for the Milestone II SSMP be waived.

The AFAS/FARV PMO is using an innovative acquisition strategy which will benefit in cost and support savings by allowing the contractor to use commercial business and manufacturing practices rather than those dictated by the Government. In an effort to delete the requirement for a "\$400 hammer," the AFAS/FARV program has provided the contractor with standards of performance and will allow the contractor to determine how best to design the system to achieve that goal. The Integrated Product Development Team approach will allow significant Government involvement in the parts selection process. It was requested that the formal DoD Parts Control Program be waived in lieu of the attempt by PMO AFAS/FARV to reduce the cost of the system by using sound commercial practices and support the goal of the Army by streamlining the acquisition process.

The AFAS/FARV Program is structured with minimum contract data deliverable requirements. The end result will be achieved through use of best commercial practices rather than requiring extensive, costly deliverable data. The Integrated Product Development Team approach will allow the Government to be aware of contractor progress on a real time, proactive basis. This will reduce the need for contractor effort spent preparing formal reports and Government resources spent reviewing these reports. It was requested that the Management Decision Authority exempt the AFAS/FARV program from this requirement.

PM AFAS/FARV plans to tailor the documentation requirements to the specific needs of the program. It was requested that the rigid software documentation requirements be waived in

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lieu of a tailored approach which is consistent with requirements of the program and sound commercial practices.

### *x. Other Streamlining Initiatives*

Other streamlining initiatives being considered in this procurement include:

- Using a performance-based RFP rather than a "how-to" approach.
- The use of a Government-prepared example SOW allowing the contractor to prepare the detailed contract SOW tailored to meet unique program objectives.
- Allowing the contractor maximum possible use of commercial specifications rather than unique military specifications.
- Allowing the contractor maximum use of commercial business and manufacturing practices rather than Government-dictated practices.
- Allowing the contractor to establish contract data requirements and format and propose cost-effective alternatives to meet Government data requirements.
- Minimizing the use of GFE in order to promote a "system-level" contract approach and avoid costs for contractor control of GFE.

### *xi. Dual-Use Technologies*

The Development Phase contractor is encouraged to consider dual-use technologies and to take advantage of commercial standards and commercially available products in the consideration of their design approaches and project plans.

## **C. Cost Control Plan**

In response to the requirement contained in the AFAS/FARV Acquisition Decision Memorandum dated 4 January, 1995, Mr. Tom Lazenby of the Office of PM Crusader Business Management Division, in concert with his organization, developed the Crusader Cost Control Plan. This plan, the outline of which was briefed to Hon. Noel Longuemare, Principal Deputy Undersecretary of Defense (Acquisition and Technology) on 16 March 1995, described the Crusader Vision with respect to Cost Management, fulfilling the requirement that, "the Army shall present its unit cost control plan, including appropriate trade-off strategies and the method for setting a realistic cost target..."

The Plan contends that Cost Management is a strategic process that results in life cycle cost control and reduction. Examination of Mission, the framework for integration into the program, cost management activities before and during Milestone I, the principal components of

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the Plan, discussion of the Design to Cost aspects of the program, goal setting, design trades, and a forecast of downstream activities formed the basis of the plan, as briefed. A summary of the Plan, keyed to the aspects noted, is provided as follows:

*i. Cost Management Mission*

The Crusader Cost Management Mission is to develop, produce and field an affordable, technically-superior next generation self-propelled cannon artillery system by adopting a proactive philosophy of continuous cost control and reduction, supported by rigorous quantitative analyses of the long-term cost implications of program design, manufacturing, and management decisions. The objective is to attain optimal balance of cost and performance.

*ii. Integrated Framework and Pre-Milestone I Activities*

An integrated cost management team, performing phased activities in support of accomplishment of program milestones, utilizing a cost management system and tools describes the Crusader approach. In advance of Milestone I the focus was on establishing initial baseline and kicking off the process. Activities include the following:

- Developing an Independent Government Cost Estimate (IGCE)
- Developing a Cost Management Plan
- Identifying Initial Cost Indicators
- Preparing an Initial Life Cycle Cost Estimate
- Preparing the Phase I/II Request for Proposal.

The output of these activities will provide the visibility to reach cost effective programmatic decisions and an initial ability to assess downstream costs.

*iii. Cost Management Plans Principal Components*

The key components of our strategic cost management process include both traditional and non-traditional elements. Traditional elements include control of current contractor cost/schedule and analyses of the effects of current progress on projected cost. Non-traditional elements include ongoing assessments of design and programmatic decisions on projected costs. They also include the interactive relationship between analyses of alternative design, manufacturing, and management initiatives to reduce costs and the development, implementation and execution of specific plans and procedures to reduce cost.

*iv. Key Cost Management Activities - Phase I/II*

During Phase I/II focus will be on three areas: controlling current phase costs, actively driving down future costs, and integrating the contractor into the cost management process. Related activities will include the following:

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- Establish a Strong Design to Cost (DTC) program
- Assess contractor cost/schedule performance
- Verify cost/requirements trades
- Identify cost indicators
- Develop a cost management system
- Assess potential initiatives.

Outcomes are expected to provide visibility into the contractor's activities/decisions to ensure a cost effective program, continued assessment of down stream costs, and aggressive cost baselines. Phase I/II will reflect future oriented activities which focus on the cost impact of design decisions. The DTC aspects of the Crusader Cost Control Plan are discussed in more detail below.

### v. *Design to Cost Program*

To ensure that the Contractor is focused on cost/performance trade-offs, aggressive cost goals are being established in the RFP, for response in the Phase I/II proposal. The contract will incorporate a strong, aggressive cost component of design parameters, or DTC. Goals will be negotiated or unilaterally set by the Government in relation to any contract modifications. Trade studies will be used as design tools rather than confirmation, or a downselect, of concepts.

Phase III, the EMD phase, will be characterized by focus on a continuous and interactive emphasis on reducing and controlling current and future phase costs. The team will be aggressively engaged in activities to include:

- Continued strong design to cost program
- Assessment of contractor cost/schedule performance
- Continuous updates of the Life Cycle Cost Estimate
- Development of a robust Phase III/production cost model
- Assessment of potential initiatives.

These activities, and increasingly accurate models and tools will provide the data and system to control costs during production as well as define and focus our efforts on seeking the best value manufacturing technologies and producibility approaches.

## D. **Contractor Sources**

### i. *Sole-Source*

A sole-source contract was planned for Development Phases I and II, under the authority of FAR 6.302-1 and 6.302-3. Detailed rationale for the sole-source strategy is contained in a Class Justification Review Document for Other than Full and Open Competition, which was submitted to the Assistant Secretary of the Army for Research, Development and Acquisition on 18 May 1994.



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### *ii. UDLP Experience*

United Defense Limited Partnership (UDLP) is the only known responsible source capable of meeting the Army's requirements for this contractual action. This determination was based on the fact that UDLP is the only company that has retained a core competency for self-propelled howitzer development, coupled with the experience gained by the company in execution of the competitively awarded AFAS Advanced Technical Demonstrator contract. Therefore, UDLP is in a unique position to execute this contract.

### *iii. Subcontracting Team*

UDLP has established a principal subcontracting team possessing other unique capabilities required to meet AFAS/FARV system development objectives. The UDLP subcontractor teams takes maximum advantage of the expertise and experience acquired under previous Concept Exploration and Development (CED) efforts and other related Army combat vehicle development and production contracts. The principal subcontracting team is comprised of Teledyne Vehicle Systems (TVS), with extensive knowledge and experience in automotive technology and common chassis advanced technology transition demonstrator (CCATTD); Martin Marietta Defense Systems, the only known worldwide source for the Regenerative Liquid Propellant Gun; and General Dynamics Land Systems, with extensive knowledge and experience in heavy combat vehicle development and production. This team represents an Army investment in excess of \$700 million for the development of specific enabling technologies and capabilities for use in the AFAS/FARV system.

## **E. Industrial Preparedness**

### *i. Contingency and Replenishment*

During Development Phases I and II, the Government and contractor team will assess production planning for achieving support for contingency and replenishment objectives. These plans will consider assurances that contracts for critical component/spare and repair parts will be contracted on more than a 2-8-5 basis with accommodation for accelerated production using the third shift. These plans will also consider measures such as stockage of long lead materials to facilitate acceleration of production to support replenishment objectives. Inclusion of comprehensive Industrial Base Planning to meet and maintain requirements for contingency support and replenishment objectives also will be required.

### *ii. Production Readiness Strategy*

During the Concept Exploration and Definition (CED) phase in support of Program Decision Memorandum (PDM) I, a Production Readiness Strategy (PRS) document was prepared and will be maintained throughout the development process to guide the management approach for ensuring that an integrated project plan is developed to support readiness for production objectives. In particular, the strategy is to ensure that the prime contractor considers using the

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existing Government production base facilities (i.e., Watervliet Arsenal, Rock Island Arsenal, Lima Army Tank Plant, Detroit Arsenal Tank Plant, Letterkenny Army Depot, and/or Anniston Army Depot).

### iii. *Industrial Base*

The initial industrial base analysis, documented in the PRS, revealed that the above Government-owned, Government-operated (GOGO) and Government-owned Contractor-operated (GOCO) facilities are available for the AFAS/FARV system acquisition throughout the development and production cycle. The analysis revealed that minimal facility investment will be necessary to handle any anticipated systems designs at the projected production quantities. The prime contractor will be required to consider using GOGO and GOCO facilities to support its manufacturing, maintenance, and production requirements, and, if they are not used, to provide an economic analysis indicating that another site is more cost-effective.

### iv. *Enabling Technologies*

With respect to a Contractor-owned Contractor-operated (COCO) facility, the initial industrial base analysis focused on enabling technologies required to meet critical operational requirements of the AFAS/FARV. These included the RLPG and associated propellant, the ammunition handling system, the automotive propulsion system, and the vehicle electronics suite. The analysis revealed that there exists a sufficient vendor base to manufacture and sustain the required projected fielding quantities.

### v. *Resources*

The US industrial base also possesses sufficient resources to fabricate and assemble complete ground combat vehicles. Martin Marietta Defense Systems, under its existing armament contract, has developed an extensive precision machining capability at its Pittsfield, Massachusetts, facility, as well as a vendor base for manufacturing precision RLPG components and transmissions for the Bradley Fighting Vehicle. TVS has produced over 4,000 hydroneumatic suspension units since 1980 and has an extensive production facility. Motor Wheel Corporation, one of the largest manufacturers of steel-styled wheels for automobiles, has an extensive demonstrated production capacity. The Joint Project Office, a joint venture consisting of Textron Lycoming and General Electric turbine engines, has produced several primary propulsion systems for ground combat vehicles (e.g., AGT 1500, and Allison has extensive manufacturing capacity to produce transmissions for ground combat vehicles). General Dynamics Land systems has successfully produced an extensive number of heavy ground combat vehicles, such as the M60 and M1-series tanks.

### vi. *Maintenance Capabilities*

Both Anniston Army Depot and Letterkenny Army Depot have been involved in the overhaul and maintenance of complete combat vehicles and their components of all weight classes. In particular, Letterkenny is presently responsible for the overhaul and application of

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product improvement kits to the M109-series vehicles undergoing conversion to the M109A6 Paladin configuration.

### *vii. Manufacturing Technology (MANTECH)*

Based on the current operational requirements and the PM's assessment of the best technical approach to achieve these requirements, the following candidate MANTECH project thrust areas have been identified. This list will be updated as the project progresses through Development Phases I, II, and III.

#### Advanced Materials And Coatings

- High/low contraction chrome - cannon tube assembly
- Ceramics, inconel; and stainless steel - RLPG, armor, and propulsion systems
- Titanium chassis (super plastic forming) - vehicle structure

#### Composite Materials - Gun Tube, Armament, And Vehicle Structure

- Militarization and compact components - vehicle electronics
- Microprocessor recoil control - AFAS gun mount
- Gallium arsenide monolithic microwave integrated circuit - multi-option fuze for artillery (MOFA) fuze

#### Battlefield Robotics Thrust

- Physical labor reduction - ammo handling
- Battlefield environment awareness - decision aids and survivability

### *viii. Title III Project*

None have been identified to support AFAS/FARV.

## **F. Competition**

### *i. Competitive Prototyping*

While it is normal that development of competitive prototypes may be a cost-effective acquisition strategy over the long term of a project, it was not a practical approach to the Development Phases of the AFAS/FARV project. In order to offset the large up-front cost increase normal to competitive prototyping (estimated to approach \$1 billion for fiscal years 1995-2000), the Army would have to realize significant savings in subsequent phases of the project. Sufficient savings are unlikely, because two of the highest cost areas (RLPG and

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propulsion account for a significant portion of the system acquisition cost) do not benefit from a competitive prototyping strategy. As stated earlier, Martin Marietta is the only company in the world with the technology and know-how to develop the RLPG. Thus, parallel development of RLPG prototypes by competing contractors is not possible. Therefore, much of the acquisition cost (in Phase III, LRIP and production) is not influenced by competitive forces. Given the relatively low production quantity anticipated for AFAS and FARV (824 each), it is highly unlikely that a competitive prototype strategy would be cost effective when compared to the current strategy. Further, given the current and expected budget environment, it is unlikely the Army will identify an additional \$1 billion for AFAS/FARV Development Phases I and II in exchange for an uncertain return on investment.

### *ii. Development Phases I and II*

The Army's original planned strategy in 1992 (as part of the ASM project) was to award a competitive Dem/Val contract for the next step in the development of AFAS/FARV, for which there were a number of contractors logically available for competition (e.g., Food Machinery Corporation [FMC], Teledyne Vehicle Systems [TVS], BMY-Harsco, General Dynamics Land Systems [GDLS]), and potential teaming arrangements, such as Armored Vehicle Technology Associates (AVTA), which is a joint venture between FMC and GDLS. During the period 1993-1994, the combat vehicle industrial base significantly declined due to industry downsizing and restructuring (acquisition, merger, consolidations, plant closing). As a result, a meaningful competitive environment for the AFAS/FARV project at the prime integrating contractor level became difficult. Combining the strengths of the remaining viable prime contractors (UDLP, Teledyne Continental Motors [TCM], and GDLS) was the best overall technical and cost solution for the project.

### **G. Program Office Estimate (POE) for AFAS/FARV**

#### *i. Likely Project Total Cost*

The POE was developed based on the Government's best technical approach in preparation for the Milestone I decision. This estimate was submitted to the US Army Cost and Economic Analysis Center (USACEAC) for review and presentation to the Assistant Secretary of the Army for Financial Management through its Cost Review Board (CRB). After review, adjustments by the CRB, and approval by the ASA(FM), the POE was changed accordingly and became the Army's official cost position for the AFAS/FARV system.

#### *ii. Independent Government Cost Estimate (IGCE)*

In order to facilitate the acquisition and streamlining of the AFAS/FARV process, the Honorable Gilbert R. Decker, the Assistant Secretary of the Army, Research, Development and Acquisition, sent a memorandum to the Under Secretary of Defense for Acquisition requesting that the Army's RFP be released and cited the need for an IGCE and how it would assist in establishing the Army's best cost position. See the memorandum on page I-69. Initially, a detailed economic analysis was not planned because the Army believed that the sole-source



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approach was comparable to the competitive approach due to the benefits of a more efficient development start-up and awarding the initial contract at a more realistic price. Additionally, the sole-source approach avoids costs of approximately \$30 million in bid, proposal, and evaluation; duplication of \$150-200 million investment required by the competing contractors to establish a full system capability; and enables the Government to capitalize on a prior investment of over \$700 million by providing for continued participation of a team of contractors who have been pursuing AFAS/FARV-related technology.

### iii. AFAS/FARV Economic Analysis

In lieu of mandated requirements to conduct economic analyses on all investments, the Project Office contracted an independent contractor for an AFAS/FARV acquisition strategy economic analysis. The economic analysis was completed and delivered in a formal report and briefing on 26 September 1994. The economic analysis considered three alternative AFAS/FARV Phase I and II development acquisition strategies. Alternative 1 was the competitive award of a combined AFAS/FARV Phase I and II contract to a single prime contractor. Alternative 2 was the competitive award of two parallel combined AFAS/FARV Phase I and II prime contracts. Alternative 3 was the sole source negotiated award of a combined AFAS/FARV Phase I and II contract to a single prime contractor and selected major subcontractors. Alternative 3 became the potential strategy when a decline in the combat vehicle industrial base made a meaningful competitive environment at the prime integrating contractor level problematic.

### iv. Economic Analysis Results

The results of the economic analysis are shown in the following table. The data are presented as net present value computed at the midyear with year one in 1995. The analysis concluded that operations and support costs would not be measurably impacted by any of the alternatives selected.

NET PRESENT VALUE - \$M			
	ALT 1	ALT 2	ALT 3
Development	2,014.3	2,658.5	2,104.2
Production	5,940.8	5,940.8	5,637.1
Opns and Support	5,042.0	5,042.0	5,042.0
<b>TOTAL</b>	<b>12,997.1</b>	<b>13,641.3</b>	<b>12,783.3</b>

Alternative 1 has the lowest development cost because Alternative 2 has duplicate costs for each contractor, and Alternative 3 has added cost for prime contractor burdens. Alternative 3 has the lowest production cost because it retains the option of competition for production that is better than the other alternatives. The bottom line is that Alternative 3 has the lowest cost but the difference is not significant in relation to the total life cycle cost of the weapon system. Alternative 2 exceeds the budget and programmed dollars. The choice between Alternative 1 and Alternative 3 was based on the lowest cost, the least technical and schedule risk, and the greatest external benefit to the Government. Alternative 3 has the least risk because of the advantage of

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the large investment already made in the AFAS/FARV concept definition and technology demonstration. It is also the best alternative to extend and maintain the armored combat vehicle industrial base. The Economic Analysis recommended Alternative 3 as the AFAS/FARV acquisition strategy and was approved by the AAE and DAE.

### H. Contract Award

#### i. UDLP

The prime contractor for both the AFAS and FARV systems is United Defense, Limited Partnership (UDLP). See page I-34 for the details. UDLP and its subcontractors must satisfactorily demonstrate in the proposal that it has the capability and planned capacity to conduct the required full spectrum of research and development, system engineering, prototyping, and initial production and fielding support.

#### ii. Contractor Risk

The risk of the single contractor approach is mitigated primarily by extensive development and demonstrations as part of AFAS/FARV CED, as well as the CCATTD project. The extended length of Development Phases I and II will provide an opportunity for continued technology maturation and optimization, thereby further reducing risk upon entry to Development Phase III. The planned testing project and concurrent engineering approach culmination in the Early User Test and Experimentation (EUTE) of both systems will ensure the developmental risks are well known and manageable prior to continuing into Development Phase III.

#### iii. AFAS/FARV Risks

The primary risks for AFAS are the development and integration of an RLPG capable of supporting the required firing rates, pumping of propellant at firing rates, development of non-ballistic survivability suites, and vehicle combat-loaded weight control. For FARV, primary risk areas consist of developing and integrating automation and/or robotics systems capable of safely storing, transporting, and transferring liquid propellant and fuzed projectiles in the quantity and at the rates required. Both systems must address the risks of computer hardware and software integration and developing an advanced propulsion system capable of providing mobility compatible with the maneuver force.

#### iv. Competitor Systems

The Army will continue to evaluate the potential for possible competitor systems to meet AFAS and FARV requirements. During the engineering trade-off analysis portion of the Cost and Operational Effectiveness Analysis (COEA), the Army examined potential foreign and domestic howitzer candidates. All were found to be substantially lacking compared to critical user requirements for range, rate of fire, survivability and mobility. During Development Phase I, culminating at the internal PEO/Commandant, Field Artillery School review of technology

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maturation and simulation efforts, engineering trade-off analysis of potential alternatives to the liquid propellant-based AFAS will be refined. The Army will conduct comparative analyses of the leading foreign candidate to determine how well it may meet User requirements, and how costly and extensive the modifications will be needed to "Americanize" the system and to upgrade it to achieve user requirements. It is significant that none of the known foreign alternative systems have a companion resupply vehicle, which is a vital element necessary to ensure that the AFAS can keep up with and support a highly mobile M1/M2-equipped force.

The PM will use internal project office data, reports from official test agencies, and support from independent sources such as the Army Materiel Systems Analysis Agency to form the basis of its report to the Army Acquisition Executive. Regarding the key performance parameters and the basis for judging the potential cost/performance trades, the RFP and Operational Requirements Document (ORD) contain performance requirements for the system. The Phase I contract will require the contractor to develop the actual technical performance measures to assess the performance maturation of the AFAS/FARV system. These measures will be used to evaluate the performance of the alternative systems. Also, the Army will use this information as the basis for updating the alternative systems analysis in the COEA before the Defense Acquisition Executive go-ahead IPR at the end of Phase II.

### v. *Testing of Competitor Systems*

Concerning the timing of the alternative system testing, the acquisition strategy provides for component and subsystem testing and initial alternative system comparative analysis during Phases I and II. The complete AFAS/FARV prototypes will not be available until FY99, at which time comparative tests will be performed with available alternate systems unless the Army's analysis indicates that actual testing of alternatives would provide no value to the Milestone decision process.

### vi. *Competition*

Competition has been an integral part of the AFAS project since its inception. Full and open competition with formal source selection procedures were used in the CCATTD contracts to TCM and AVTA in December 1990. Also, the AFAS Advanced Technology Transition Demonstrator (ATTD) contract was competitively awarded to FMC in May 1991.

## I. **Diesel and Turbine Engines and Evaluation Alternatives**

In a memorandum from the Deputy Under Secretary of Defense (Acquisition and Technology) to the Army Acquisition Executive, 30 December 1993, the Army was directed to evaluate alternative diesel and turbine-type engine candidates as part of the proposal evaluation process. During the contract definition phase, the contractor/Government team will prepare a comparative analysis of the benefits and burdens of both the diesel and turbine candidates and select a propulsion system that best meets the requirements of the AFAS/FARV project and is consistent with the Army's long-range plans. This selection, along with the detailed analysis and selection criteria will be presented to a Propulsion System Evaluation Board which will review

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consistent with the Army's long-range plans. This selection, along with the detailed analysis and selection criteria will be presented to a Propulsion System Evaluation Board which will review and ratify the selection. The final engine selection decision will be made by the Army at the same time as award of the Development Phase I and II contract. The results are at Section 16, page I-78.

### **J. Technology Forum**

To promote competition, a technology forum was hosted in April 1993 for all interested and potential AFAS and FARV contractors to review the status of current AFAS and FARV developments performed either by the Government or under Government contract. This four-day forum described development work in the areas of firepower, resupply, survivability, and mobility. Also, an unclassified, electronic repository for the deliverables under past and current efforts was established to enable qualified bidders to obtain the latest data available from Government and Government-funded industry efforts.

### **K. Program Executive Officer (PEO)/Commandant IPR**

Prior to transitioning from Phase I to Phase II, the Contractor will schedule and support a PEO/Commandant IPR. Prior to the IPR, the Contractor is to demonstrate that the Phase I objectives and Transition Criteria delineated in the SOW, IMP, and IMS have been achieved. As the principal objective of the PEO/Commandant IPR, the Contractor will demonstrate through a combination of techniques including simulation, modeling, mock-ups, analysis and test that: (a) Transition Criteria have been achieved; (b) the system concept and design approach to be implemented in Phase II have been validated to the maximum practicable extent; (c) component technologies are on their projected growth paths; and (d) program/technical risks are manageable. Successful completion of the PEO/Commandant IPR will be the basis for proceeding into Phase II. The Contractor will provide a comprehensive review of Phase I development efforts, focusing on the accomplishments and status of the following:

- "Process" engineering activities
- "Product" engineering activities
- System simulation and modeling, focusing on virtual prototyping and Battle Lab activities
- Component maturation activities, focusing on performance and risk reduction objectives.
- Primary Armament and System Integration Laboratory performance and risk reduction objectives



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- Demonstration of "Transition Criteria"
- Test Accomplishments

In addition, the review shall include a "look back" assessment of key development tools/techniques including the Product Development Team (PDT) approach, the Contractor Integrated Technical Information Services (CITIS), Government/contractor partnering, product quality, continuous process improvement, and overall customer satisfaction.

### **L. Development Phase III and Production**

#### *i. Strategy*

A sole-source system contract will be awarded to UDLP for the combined AFAS and FARV efforts, although the Army will reserve the right to revisit a competitive award for Phase II at the conclusion of Phase I. The strategy is intended to establish a long-term partnership, ensuring the participation of the AFAS and FARV Development contractor through Low-Rate Initial Production (LRIP). Linkage of the contractor's award fee to performance, measured against the contract Technical Performance Measures, will ensure that the contractor remains sensitive to the Army's needs throughout the Development phases of the project. Competitive sources for subsystems and components will be emphasized throughout the project via appropriate award fee criteria with component breakout remaining an option during production and sustainment. Before entering Development Phase III, the Acquisition Strategy Report will address the Major Programs Competitive Alternate Sources requirement (10 USC 2439).

#### *ii. Multi-year Procurement*

During the production phase of the project, the PM will seek approval for multi-year procurement in order to achieve economies of scale by allowing the contractor to plan for larger quantities, make appropriate capital investment decisions and long-term subcontract agreement, and order economical quantity purchases of material and components. To facilitate a timely release of the production RFP, a waiver will be requested permitting the RFP release prior to the MS III decision.

### **M. Contract Type**

A Sole Source Cost Plus Incentive Fee with Award Fee Provision is contract planned for the AFAS and FARV Development Phases I and II effort. The incentive fee will be applicable to cost control, while the award fee will be based on a compilation of aspects of project success related to technical, management and cost goals. A significant award fee will be extended to the contractor if it consistently manages cost while achieving project technical objectives and schedule requirements. Also, high fees resulting from aggressive share ratios will be extended if the contractor completes the contract under the target cost. Alternately, the contract will mandate

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award and incentive fee reductions for failure to properly manage cost, or make satisfactory technical or schedule progress, or for overrunning the target cost. The process will require the prime contractor to submit a proposal that will define the statement of work and the project plan responsive to the Development Phase I and II RFP. This contract definition phase has been initiated and will conclude with the delivery of the Phase I and II proposal in August 1995. The proposal will become the baseline statement of work from which the contractor and the Government will independently develop cost estimates for the contract. A contract award was scheduled for October 1995.

### N. Lessons Learned

#### LESSONS LEARNED - STREAMLINING

- The desire to save time and money through streamlining the administrative process cannot override/neglect the time needed to eliminate technical risk.
- Detailed planning and coordinating from the Program Office with DA and OSD were required to achieve Army Lead Program status and entry into a streamlined requisition process.
- The more than \$700M invested in pursuit of the many core and enabling technologies to support this complex acquisition requires (and absorbs) significant resources.
- Competition, where logical, is still a powerful cost-driver, but applying Deming's principle of "the proven few," returning competition options downstream appears right for the Crusader development.

## 6. RFP DEVELOPMENT

### A. Initial RFP Development

Initially, the RFP development was being done independently by the AFAS and FARV program offices. Mr. Kevin Holmes was the Technical Team Chief for the RFP Development when the next RFP development effort was started. This effort, initially an RFP for the AFAS, turned out to be futile because the team members were from the FARV program office and were not well versed on the technical aspects of the AFAS. Also, the team members were receiving conflicting guidance from the FARV program office. Another problem was that the team was held in sequestration during their efforts and were unable to interact with the IPTs, because neither of the two PMs had fully bought into the IPT concept. Because of this, six to eight months were lost on the efforts for this RFP.

It was in January 1993 that the Draft RFP went out on the electronic bulletin board. However, it was not balanced because there was difficulty in obtaining the necessary AFAS/FARV requirements - but, the two PMs became excited because Industry was actually reading the RFP. The problem was that there still were no funds for FARV.

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### **B. RFP Progress**

It was not until LTC William B. Sheaves III came on board in June 1993 before the RFP efforts became meaningful. Anything that pertained to Dem/Val had to be included in the RFP. This included streamlining initiatives and the acquisition strategy. The decision was also made to develop one RFP for both programs because of commonality of the two systems. Resources were pooled to solve issues that were necessary to get to the required Milestone. One point of contact (POC) from each PM program office was selected to ensure progress and coordination for the formal source selection process. Daily and weekly meetings were held on specific sections of the RFP.

Work Breakdown Structures (WBS) were a continuing problem and time consuming because it was hard to get a unanimous decision on a WBS that would be accepted. Conferences and working group sessions were held with the Project Manager officer personnel to resolve issues on the WBS elements. Sequestered reviews were held in November 1993 and again in April 1994 to finalize the WBS foundation and develop a sample SOW to meet the minimum set of Government regulations. The changes in the WBS, which will continue to change, will continue as the contractor identifies efficiencies. The more time the PM personnel spend at UDLP, then the WBS will merge and settle down. Also developed during this time was guidance on the process/activities for the Government to monitor and oversee during Dem/Val.

During February and March 1994, a final acquisition strategy was developed that would work within the Army and also accepted by Headquarters Department of the Army (HQDA) and OSD. The competitive RFP was then changed to a non-competitive RFP acquisition strategy. In April 1994, the RFP team had two RFPs ready to distribute pending a final decision from HQDA. When the new acquisition strategy RFP was approved, it was distributed in July 1994.

With the AAE IPR and the DAE IPR replacing the ASARC and DAB respectively, it was now possible to proceed with the Senior Level Integrated Product Team Coordinating Council (SLICC) for the AFAS/FARV systems. See page I-72 for details of the SLICC.

### **C. RFP Team**

LTC William B. Sheaves III - Development Project Officer

#### Team Members:

Mr. Jay Amin  
Mr. Cliff Daley  
Ms. Nan Holder  
Mr. Mike Smurla  
Mr. John Theis  
Mr. Kevin Leondi  
Mr. Jim Gaida  
Mr. Bruce Bernardo

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**D. Lessons Learned**

**LESSONS LEARNED - RFP DEVELOPMENT**

- The FARV background did not prepare the team to write an AFAS RFP.
- The first RFP was only 5% valid.
- The IPTs made significant of progress in a short time with proper planning and well-chosen staffing.

**7. PROCUREMENT CONTRACTING OFFICER STRATEGY**

**A. Procurement Contracting Officer**

*i. Contractors' Work Session*

On 14 April 1994, Mr. Jeffrey M. Boyle, Contracting Officer at Picatinny Arsenal, sent a letter to each of the prospective AFAS/FARV contractors regarding a contractor working session to be held at Picatinny Arsenal at 0900 18 April 1994. This letter was based on discussions with the contractors regarding the AFAS/FARV acquisition strategy. The contractors had recommended that the Army explore a noncompetitive strategy that would fully capitalize on the significant investments made in the ASM project. Such a strategy could also enhance the industrial base by maintaining capabilities, expertise, and facilities that could be put at risk or lost if certain firms are not selected for award.

*ii. Contractors' Meeting*

This meeting, among contractors only, was to give the contractors an opportunity to develop their concept of a noncompetitive strategy that accomplishes the above goals and develop an optimum weapons system. The invited contractors were United Defense, Limited Partnership, Teledyne Vehicle Systems, General Dynamic Land Systems, and Martin Marietta Defense Systems.

*iii. Strategy/Agreements*

The contractors were instructed to prepare and submit their concept of an optimum strategy and draft agreements defining who would have system prime responsibility. They were to outline the roles and relationship among the contractors, appropriate work share (i.e., the activities/efforts which each team member would be performing by WBS element as defined in the draft RFP), project organization charts, plans to manage and control costs, and any other documents necessary to convey a full understanding of their concept. In describing their relationship, they were advised that the Watervliet Arsenal would be mandated by the Army as the required site for the eventual production of gun tubes. Also, the Lima Tank plant was to be



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considered and used for production of the AFAS/FARV system unless other solutions were more advantageous to the Government.

### *iv. Contractor Discretion*

The contractors were also cautioned to take no action that would preclude or compromise pursuit of a competitive development strategy. Examples of information that could not be disclosed among the parties were competitive proposal strategies, proprietary technical data, pricing information and strategies, manning levels, and similar competitive or sensitive strategies. In the event that the Government decided to pursue a competitive strategy, Martin Marietta was designated as the directed subcontractor for the RLPG primary armament subsystem. The RFP was revised to reflect this government decision.

### *v. Noncompetitive Strategy*

The contractors were advised that the Army had been authorized by the Acting Under Secretary of Defense for Acquisition and Technology (USD)(A&T) to explore a noncompetitive strategy for the AFAS/FARV development project. The authority did not preclude potential competition for production. Under the conditions and in light of the authorization granted by the Acting USD (A&T), the Department of Justice raised no objection to the Army's noncompetitive strategy proposal.

### *vi. Conclusion/Agreement*

The contractors were requested to conclude their deliberations by the close of business 27 April 1994 and to provide a briefing to the Army at the Pentagon on 28 April 1994 on the results. An agreement was reached by the four contractors and they briefed their concept to the Army on 28 April 1994. United Defense (FMC/BMY) was selected as the prime and the other contractors selected to subcontract to UDLF.

### *vii. Contractors' Briefing to AAE*

The main topic of the briefing was "**Why Do This?**" The rationale for the proposed team was outlined in four key areas:

- **Retains Critical Skills and Facilities.** The Lima tank plant and Watervliet Arsenal would remain intact and the combat vehicle industrial base would be maintained.
- **Reduced Schedule Risk.** This proposal would accelerate the time to meet milestone II/ milestone III criteria and would ensure maximum industry and Congressional support for the project.
- **Reduced Technical Risk.** All key AFAS/FARV related technologies have been developed by the Team and all the critical skill sets are in the Team.

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- Reduced Project Cost. The competition is retained at the line replaceable unit level and the Team members' scope of work will match their existing capabilities. This sole source leverages all prior major AFAS/FARV related Government and contractor prior investments (\$565M and \$75M respectively), reduces Government resources required for proposal evaluation, and minimizes project costs because existing facilities and capabilities are optimally applied to the project.

### *viii. Contractors' Strategy*

The following were the principles of the contractors' AFAS/FARV acquisition strategy:

#### Phase I

- Use of an integrated product team (IPT) development approach
- Normal demonstration/validation activities - component maturation
- Early focus on analysis and simulation
- Battle lab interaction
- Maximum use of concept exploration phase technologies
- Transition to Phase II requires PEO approval

#### Phase II

- Fabricate the AFAS and FARV limited prototypes
- Conduct contractor, Government and early user testing
- Continue simulation and modeling to verify overall effectiveness
- Transition to Phase III requires Defense Acquisition Executive approval
- Prepare Phase III proposal

#### Phase III

- This is full system development and pre-production (EMD)
- Transition to LRIP requires Conventional Systems Committee approval

#### Low Rate Initial Production

- Initiate during Phase III
- Conduct initial operational test and evaluation

The following were the principles of the contractors' AFAS/FARV industry team strengths:

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### United Defense LP

- Large Caliber Armament Systems
- Combat Vehicle Systems
- Automated Ammo Handling
- Advanced Vehicle Structure Design

### Teledyne

- Advanced Automotive Technologies
- Survivability

### Martin Marietta

- RLPG Technology Maturation
- Artillery Resupply
- Vehicle Subsystems

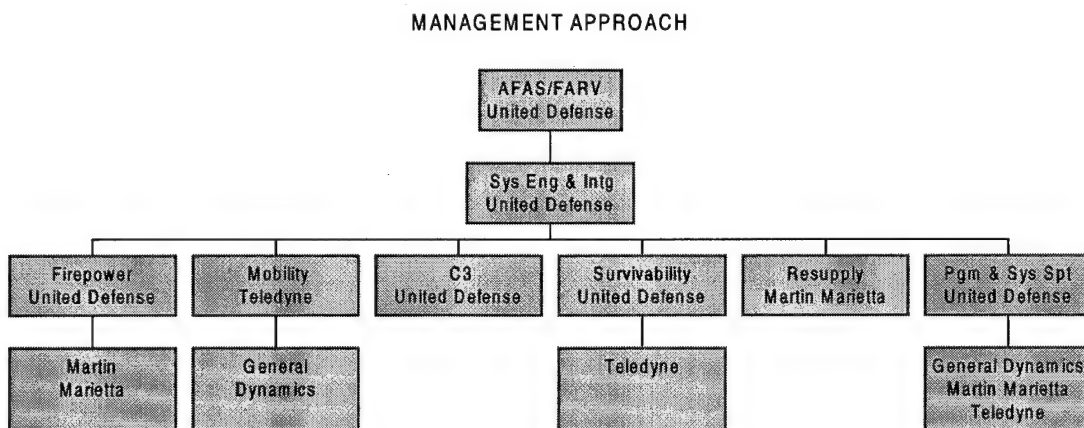
### General Dynamics Land Systems

- Manufacturing at Lima Tank Plant
- Tactical Communications

### *ix. Contractors' Management Approach*

The management approach, Integrated Product Development Team (IPT) that the contractors selected for the AFAS/FARV industry team and the PM's Project Schedule used by the contractors for their teaming effort are shown below.

The contractors' management approach was based on the project schedule developed by the PM AFAS/FARV. Both are shown below:

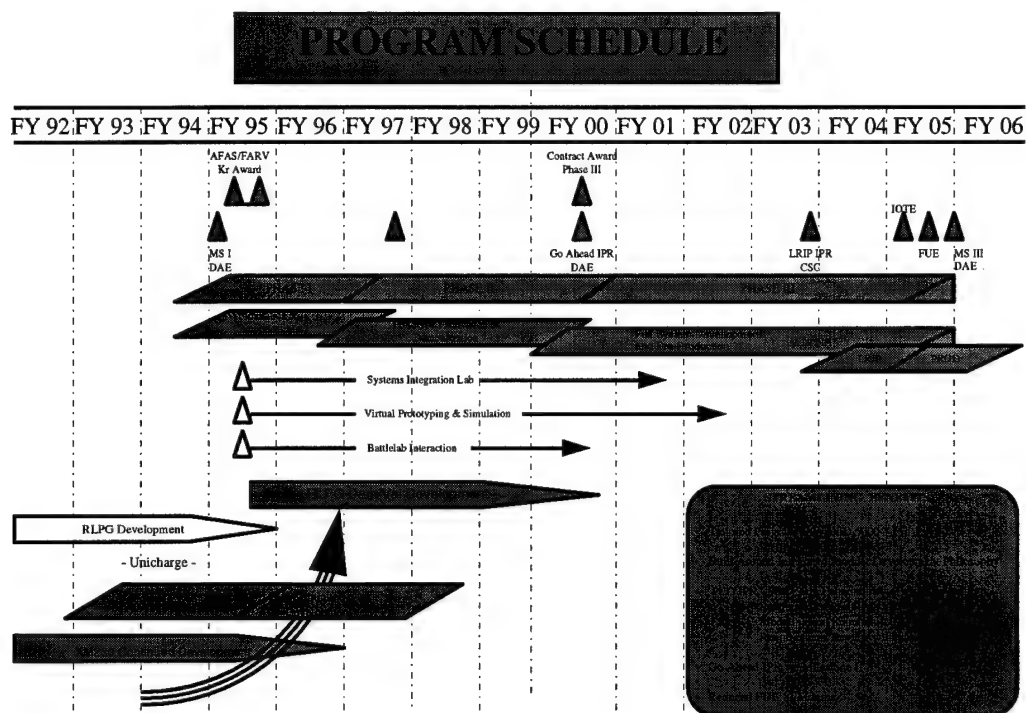


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## B. Lessons Learned

### LESSONS LEARNED - CONTRACTOR STRATEGY

- Excellent example of how industry and the Government can work together.
- The Procuring Contract Officer's (PCO's) expectations about outcomes and relationships were not communicated, nor fully realized as a result of the sole-source direction. One result was expensive general and administrative (G&A) stacking. Without competition for subcontractors, several layers of overhead burden the present relationship.

## 8. ARMY ACQUISITION EXECUTIVE

### A. OSD Memorandum

#### i. Industrial Base Sustainment Strategy

On 6 May 1994, the Honorable Gilbert F. Decker, Assistant Secretary of the Army (Research, Development and Acquisition) signed a memorandum for the Acting Under Secretary of Defense (Acquisition and Technology), SUBJECT: Advanced Field Artillery System. The memorandum was a follow-up to their 29 April 1994 meeting concerning the Army concept for



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an Advanced Field Artillery System/Future Armored Resupply Vehicle (AFAS/FARV) industrial base sustainment strategy.

The memorandum addressed concerns regarding the process and controls the Army would use to ensure that the target cost for the AFAS/FARV would be fair and reasonable assuming a potential contractor cost bias due to the absence of competitive bidding.

### *ii. Independent Government Cost Estimate*

Mr. Decker stated that the Army's detailed Independent Government Cost Estimate (IGCE) for the Dem/Val phase of the AFAS/FARV project would serve as the yardstick for assessing both realism and reasonableness of the contractor's cost proposal. It would be the basis for the Army's cost position during negotiation of a fair and reasonable price, including target cost, for this significant developmental effort. It would be as accurate as state-of-the-art cost estimating techniques allow. To ensure the best possible cost estimate, the Army would prepare the IGCE using proven cost estimating techniques; its accrued wealth of experience and information gained from years of developing and procuring combat vehicle systems and personnel from USACEAC and the Army Materiel Command, along with support from an experienced, independent consulting contractor (Science Applications International Corporation (SAIC)).

Special precautions that would ensure a quality IGCE - one that would facilitate the detection of any "high-ball" contractor cost estimate are described in the following paragraphs.

### *iii. IGCE Parallel with Contractor*

The Army's IGCE would be developed in parallel with and concurrent with the contractor's preparation of detailed technical and cost proposals. As the system configuration materializes during this initial design phase, the Army's cost estimating team would be incrementally provided with system information and details (without cost data) that would allow the IGCE to be formulated and then refined as the contractor's efforts progressed. The objective would be to have a fully developed and supported IGCE just prior to the contractor's formal proposal submission. This approach would ensure that the IGCE and the contractor's proposal are fully consistent with regard to system configuration and project work content. With this information, the Government would be able to develop estimates for labor hours, labor rates, risk allocations, indirect rates, and material costs.

As the Army Acquisition Executive (AAE), Mr. Decker stated that he would have the final decision on the Army's contract cost position. The Army's data estimates, methodology, and assumption would be available for review by OSD at any time during or after the estimating process.

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iv. *Contract Type/Incentives*

Upon establishing a sound contractual target cost position, the final step in the process would be to negotiate effective cost incentives. The Army contemplated using a Cost Plus Incentive Fee with Award Fee (CPIF w/AF) contract for the Dem/Val phase, which would provide adequate incentives to motivate the contractor to achieve or underrun the target cost. A significant award fee would be available to the contractor if he aggressively manages cost as he pursues both schedule requirements and project technical objectives. Additionally, a substantial incentive share ratio would provide the contractor with a generous fee bonus for completing the project under target. Alternatively, the contract would mandate significant fee reductions for exceeding the target cost.

The process, with innovations described above, would provide the Army with a solid, supportable cost position as it enters negotiations, and would ensure a fair and reasonable price for Dem/Val contract performance.

v. *OSD RFP Approval*

During and interview with SAIC, Colonel John Geis, Executive Officer (and former PM for AFAS/FARV), AAE, said, concerning the AFAS/FARV streamlining process, that the Army received a verbal response from OSD to release the AFAS/FARV proposal subject to the review and resolution of any OSD comments on the draft RFP.

**B. Lessons Learned**

LESSONS LEARNED - ARMY ACQUISITION EXECUTIVE
<ul style="list-style-type: none"><li>• IGCE is a useful and valuable tool in this acquisition strategy.</li><li>• The strategy preserves the industrial base</li><li>• The use of an experienced acquisition cost contractor to support on IGCE was quite helpful.</li></ul>



**9. ARMY/OSD INTERFACE ON DRAFT AFAS/FARV RFP**

**A. OSD Concerns and Army Responses on Draft RFP**

Following are the major concerns of OSD (3 June 94) and the Army's responses (15 June 95) concerning the draft RFP.

i. *Deputy Director, Performance Management*

Q1 The RFP does not contain a Contractor Cost Data Reporting (CCDR) Plan.

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A1 The AFAS/FARV Project Office has coordinated extensively with the Office of Assistant Secretary of Defense, Program Analysis and Evaluation [OASD(PA&E)] to develop a fully supportable CCDR Plan. Based upon input received from OSD regarding WBS reporting requirements, a final CCDR Plan has been prepared and submitted to OASD(PA&E) for review and approval.

Q2 The need for the Progress Curve Report (CDRL A005) and the Plant-Wide Data Report (CDRL A006) should be reconsidered.

A2 The AFAS/FARV Project has coordinated extensively with OASD(PA&E) to develop a fully supportable CCDR Plan and contract reporting requirements. The subject Progress Curve Report requirement is totally compliant with the direction provided by OASD(PA&E).

Q3 Recommend that the Cost Performance Report (CPR) CDRL (A001) be tailored to address the specific information needs of the project office.

A3 The CPR described in the solicitation has been prepared based on the information presently available without the specific knowledge of the contractor's proposal. Specific tailoring of the CDRL items (i.e., CPR) will be performed after a thorough evaluation of the contractor's data management plan is assessed against Government reporting needs.

Q4 CPR CDRL requires electronic submissions. The project office should be aware that the Federal standard for electronic data interchange is ANSI X-12.

A4 The CPR CDRL and the Government Concept of Operation for the Contractor's Integrated Technical Information Service (CITIS) and the performance specification will be changed to reflect the requirement for data compatibility with the ANSI X-12 format.

Q5 In section 92000 of the statement of Work, the concept that earned value should be used as a project management tool, rather than being raised as just a reporting requirement, should be explicitly stated.

A5 Agree. The RFP has been revised to include the contractor's use of earned value in the management of the project.

Q6 For consistency, cost performance rating levels and descriptions should be added to Section H.12.

A6 Based upon the contract type, CPIF with Award provisions, contract cost is emphasized in all areas/levels of contract performance. For consistency, Section H.12 has been revised to incorporate additional Award Fee cost performance levels. The Award Fee will give the contractor incentives in the areas of management, performance, and schedule to include his cost management project. The Incentive Fee provision will provide a positive incentive for

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achieving a cost at or below target level and alternatively providing a penalty for exceeding the contract target cost.

*ii. Director, Test & Evaluation, Land & Maritime Programs*

Q1 On page C-6, AFAS/FARV - A Project Structure, the schedule indicates that the RFP decision and the FUE will occur before the LFT&E report is provided to Congress. This could violate Title X, Section 2366 USC provisions restricting such a move until after the report. We recommend the project schedule be amended to reflect a completed LFT&E report before the RFP decision.

A1 Agreed. The schedule has been revised to remain compliant with Title X, Section 2366. FUE will occur after the receipt of the LFT&E report. The Full Rate Production (FRP) RFP, however, will be retained in time before the MS III. It is understood that this action will require a waiver approved by the DAE.

*iii. Acting Deputy Assistant Secretary (Production Resources)*

Q1 There is no strategy for cost containment or reduction.

A1 Agreed. The ASR has been revised to state the threshold and objectives for the unit production cost of the AFAS/FARV. The Award Fee has also been revised to include contractor incentives to achieve project unit cost objectives. The Cost Control Effectiveness area found in Section H of the RFP has been deleted.

Q2 The facts presented by the Army, and other information currently available to us, do not support the Army's sole source proposal from an industrial base perspective.

A2 OPM-AFAS/FARV did not intend to imply that the contractors not selected in the competitive process would cease to be viable defense contractors. However, since the Army intends to award a Phase I and II (Dem/Val) contract which will be continued on a sole-source basis through production, it is unlikely that the losing contractors would maintain an interest and capability in Artillery related technologies. This continued expertise would require a large expenditure in R&D dollars to maintain a competitive edge without any prospect for future contracts. Therefore, if the Government decided at some time during the conduct of the contract that it was in the Government's best interest to compete subsequent phases (because of lack of cost control or technical performance) it would be highly unlikely that an adequate industrial base would be available for this competition.

Q3 Page C-11, paragraph 2.d.(6) implies that the Army plans to implement an organic depot maintenance capability for the AFAS/FARV systems.

A3 The ASR page C-16, paragraph 2.d.(6) mentions the Anniston and Letterkenny Army Depots; these facilities are available for use during execution of the AFAS/FARV project,



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if necessary. It was not intended to imply that a depot support strategy had been developed for the AFAS/FARV system.

Q4 The RFP seems to indicate that supportability is an integral part of the early design phases. The ASR, however, does not address supportability as part of the early design efforts.

A4 Although not specifically stated, areas such as support and manufacturing design, etc. are inherent in the Integrated Product Team (IPT) approach. The ASR has been revised to identify support concerns in the early phases of development.

Q5 Page 2: RFP concerns.

A5 The RFP structure requires the offeror to define his approach and tasks required to meet Cost/Schedule and Performance objectives. The produceability approach and transition from Phase I to Phase II is required as an input to the offeror's proposal. The contractor will also describe in his proposal how he plans to implement the Integrated Product Teams. These will be evaluated with the Offeror's proposal for Phase I and II. The tenets of TQM are an integral part of the IPT philosophy and that of the OPM-AFAS/FARV. Additionally, the RFP has been changed to include Design to Unit Production Cost as a trade-off criteria.

iv. *Deputy Director, Acquisition Systems Management*

Q1 Lack of economic analysis...Thus, Army is still asking the Principal Deputy Under Secretary of Defense (PDUSD) (A&T) to approve an acquisition approach without providing substantive rationale. At the very least, Army should provide a copy of the Army Competition Advocate's determination.

A1 An economic analysis delineating the comparison of the non-competitive versus competitive acquisition strategy is being prepared by OPM-AFAS/FARV. Completion of this analysis is expected in early July. Upon completion and approval by the Army, it will be provided to OSD for review.

Q2 Testing of alternative systems. Rather than describing a project structure that includes alternative system testing, Army implies that "actual testing" may never be done. "The complete AFAS/FARV prototypes will not be available until FY99, at which time comparative test could be performed with available alternative systems..." The language implies that Army is not taking alternative systems seriously.

A2 Agreed. The complete AFAS/FARV prototypes (available in FY99) will participate in comparative testing with alternative systems. This alternative comparative testing concept is reflected in the ASR.

Q3 Unit production threshold. The ASR does not provide a unit production cost threshold. Again, the need for this important item has been previously discussed.

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A3 The ASR has been amended to reflect the OPM-AFAS/FARV Design to Cost (DTC) project objectives and plan. Also included are both an estimate of the Design to Unit Production Cost (DTUPC) objective and threshold values. A Design to Unit Prototype Manufacturing Cost (DTUPMC) has been incorporated into the Phase I and II (Dem/Val) and is planned for Phase III (EMD) to establish data points along the cost maturity curve in order to assess the contractor's progress in meeting DTC objectives.

Q4 Integrated team approach. The ASR does not describe how the Government will control costs under the integrated team approach. Specifically, the concern is that Government-to-contractor "open communication" could translate into chargeable work.

A4 The RFP has been amended to reflect an additional clause in Section H.15. Also, OPM-AFAS/FARV will have at all integrated team functions, procurement representatives present, to ensure that Government-to-contractor communication cannot be translated in a "constructive change."

v. *Director, Defense Procurement*

Q1 The ASR refers to a "contract definition phase," but it does not define what activity will be conducted during this phase nor why it is necessary. Its purpose appears to be to pay the contractor(s) to develop a proposal for "Development Phases I and II," which would normally be financed by the contractors through indirect cost accounts for bid and proposal expenses. The ASR should better define this phase.

A1 The ASR has been changed to reflect the activities to be conducted in the phase. (see ASR page C-5).

Q2 The ASR states that the contractor's proposal will become the baseline statement of work, which the contractor will define independently during a contract definition phase. The Government should define contract work statements, not the contractor.

A2 The AFAS/FARV acquisition strategy anticipates the preparation of the SOW to be a joint effort between the Army and the contractor, with the Army clarifying requirements and the contractor translating these requirements into the project execution plan. The IGCE, however, will be independently prepared by the Army based on this baseline SOW.

Q3 The ASR appropriately notes that commonality between AFAS and FARV is a desirable system design consideration consistent with performance requirements and cost effectiveness. However, it also states "the contractor's efforts will be monitored to ensure that the highest degree of commonality is achieved between AFAS and FARV." "Any essential commonality should be mandated by the contract and not achieved by "monitoring the contractor."

A3 Agreed. The statement will be deleted.

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Q4 A proposed streamlined approach described in the ASR which includes the use of "tailored milestone documentation and reviews" during the DAE's conduct of an in-process review proposed to replace the traditional Milestone II decision. However, it is not clear what the DAE will be expected to decide at this point in the process that is different from a Milestone II decision, and it is not clear how the documentation or the reviews will be tailored. The ASR should clearly state how the documentation and reviews will be tailored to ensure that the various statutory requirements underlying DoDI 5000.2 will be met.

A4 The decision required by the DAE will be the same for either a MS II or the DAE IPR, i.e., authority to enter Full Scale Development. The ASR has been modified to clarify compliance with all statutory requirements.

Q5 The ASR states that "the ability to satisfy all AFAS system performance requirements is dependent upon the prime contractor's ability to influence the design and integration of the RLPG." The ASR should explain how UDLP Team will influence the design and integration of the RLPG being developed by Martin Marietta.

A5 Unlike a conventional (solid propellant) armament system, the RLPG is an integral part of the system, dependent and influencing the operation of various major subsystems. It is essential, therefore, that the RLPG be developed as part of the system concept and development. UDLP has established procedures and gained knowledge and experience by accomplishing the only integration of an RLPG into the AFAS Advanced Technology Demonstrator (ATD). The ASR has been changed to reflect these facts.

Q6 The ASR states that AFAS and FARV may use "an industry standard technical data package through LRIP versus a Government/DoD standard TDP." What is an "industry standard TDP" and how does it differ from a "DoD standard TDP?" Why is an "industry standard TDP" only useful through LRIP? The ASR should explain the proposed technical data documentation more specifically so there is a basis to determine that Government interests in component breakout, maintenance, repair, overhaul, and logistics support are met.

A6 The ASR has been modified to include a LCC project with emphasis on achieving design to cost and DTUPC objectives.

Q7 The ASR describes an "aggressive cost management project" that will be developed during the development Phase I and II contract. The ASR also should establish a challenging cost goal for production of AFAS and FARV.

A7 The ASR has been changed to more fully describe the definition and intent of this documentation.

Q8 The ASR states that detailed rationale for awarding a sole source contract to UDLP is contained in a proposed Class J&A. Neither the draft J&A nor the "detailed rationale" it contains was released for review, and the ASR does not present a convincing case that only

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UDLP is uniquely qualified to develop the AFAS/FARV. FAR 6.301(a) states that "contracting without providing for full and open competition...is a violation of statute, unless permitted by one of the exceptions in 6.302." The ASR cites the exception at FAR 6.302-1, "only one responsible source and no other supplies or services will satisfy agency requirements." While the ASR states that "UDLP is the only known responsible source capable of meeting the Army's requirements," it also describes how competition had been used very effectively to make earlier technology base investments related to AFAS/FARV and that unusual efforts had been taken to promote competition for AFAS/FARV development. UDLP's unique position is attributed to observations that it is "the only company in the US which has retained a core competency for self-propelled howitzer development" and that it gained experience under the AFAS ATD contract. The ATD experience did not make UDLP uniquely qualified to develop AFAS/FARV. The ASR does not describe how the "core competency for self-propelled howitzer development" will be employed in the AFAS/FARV development. Also, the reason that Army has a requirement for AFAS is that several countries have self-propelled howitzers that are superior to the US capability. There are several companies outside the US who would be qualified to develop the AFAS/FARV or provide a suitable substitute.

In addition, the ASR states "a meaningful competitive environment for the AFAS/FARV project at the prime integrating contractor level became problematic (because of industry downsizing and restructuring.)" It then mentions three remaining viable prime contractors (UDLP, TCM, and GDLS.) Hence, the ASR documents that UDLP is not the only source available.

The sole source strategy then hinges on the premise that "combining the strengths of the remaining viable prime contractors...appears the best overall technical and cost solution." The ASR states that "the sole source approach...enables the Government to capitalize on a prior investment of over \$700 million" for other programs. Prior investments are not relevant to the question of whether AFAS/FARV development should be competed because the products the Government received from those investments are available to all, so every contractor can capitalize on the investment to the extent that it may be relevant to AFAS/FARV development.

The ASR should be reviewed to include a more persuasive rationale for a sole source contract, or it should be revised to provide for competitive selection of the AFAS/FARV developer.

A8 The information and support of the sole source acquisition strategy is contained in the J&A for AFAS/FARV Phases I & II.

Q9 The ASR suggests that the prime contractor may subcontract with GOGO or GOCO facilities. The Army plans to use Watervliet Arsenal and the Lima Army Tank Plant during production, even though "the U.S. industrial base possesses sufficient resources to fabricate and assemble complete ground combat vehicles." The ASR should state that either Government facilities or products of those facilities will be provided to the contractor as GFE.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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A9 The ASR has been corrected. It should be noted that the intent of the Army was to make available these facilities rather than personnel or services (sub-contract arrangement).

Q10 The ASR rejects use of a competitive prototyping strategy under the presumption that multiple liquid propellant gun prototypes would have to be developed. However, the set of potential alternatives need not be limited to candidates which incorporate liquid propellant gun technology. There are several foreign self-propelled howitzers with performance characteristics comparable to AFAS/FARV. The advantages of a competitive prototype strategy are available to the AFAS/FARV project without the expense of multiple developments. Whether or not the AFAS/FARV contract is competed, the ASR should provide for side-by-side comparison tests of AFAS versus non-developmental systems during the development project.

A10 At the present time the ASR and RFP reflect the Army's propellant decision stating that liquid propellant (RLPG) is the choice for AFAS armaments.

Q11 The ASR states that the Phase III development contract may be competed and that "competitive sources for subsystems and components will be required commencing in Phase III." The prospect for competition for the Phase III development contract, assembling that the AFAS/FARV is found to be superior to alternative self-propelled howitzers, seems extremely remote. The ASR should either delete the reference to a competition for Phase III development, or explain in some detail how a competition will be conducted. Also, the reference to competitive sources for subsystems and components should be specific.

A11 The Army's strategy is to award a sole-source contract for Phase III (EMD). Competition at the subsystem and component level will be encouraged via appropriate use of award fee incentives.

Q12 The ASR states that alternative diesel and turbine engine candidates will be evaluated as part of the proposal evaluation process. It might be more reasonable to evaluate alternative engines later when prototypes are expected to be available.

A12 The ASR has been changed. Please see description of engine selection process on page C-21.

This office recommends the RFP be released after the following changes (C) are made and provided the Defense Acquisition Executive approves a noncompetitive acquisition strategy:

C1 The RFP must state the threshold unit production cost of AFAS and FARV. The award fee should be changed to provide a substantial incentive for achieving the threshold unit production cost. Also, the distribution of the award fee available for each evaluation period and the definition of the criteria for "Cost Control Effectiveness" should be stated.

C2 Many of the attachments, such as the Army Cost Analysis Manual and the Government Concept of Operation for Data Management, to mention but two, do not appear to

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provide direction to the contractor. In the interest of streamlining and paperwork reduction, all attachments which do not state a specific contractor performance requirement should be deleted.

C3 Attachments 14 and 15, "Test Annex" for AFAS and FARV, respectively, state "definitive test scope and coordination will be worked out between the contractor and the Government through the course of the project." The test annex should only be included as an attachment to the RFP when it includes a definitive scope for contractor performance.

C4 The need to establish a restricted industrial base for AFAS and FARV was not documented in the Acquisition Strategy Report (ASR). Clauses H.9, "Restriction of Critical Items and Components in Support of US Industrial Base," and L.10, "Base Retention Requirements," should be deleted.

C5 Paragraph b.(2) of clause L.12, "General Instructions to Offerors," indicates the planned use of contractors or consultants to evaluate proposals. Their identity and the sections of the proposal they will evaluate should be made known to the offeror. If these things cannot be stated in the RFP, recommend obtaining the offeror's consent prior to commencement of the evaluation.

C6 The ASR indicates an intent to use Lima Army Tank Plant, Watervliet Arsenal, and potentially other Government activities in connection with development of AFAS/FARV. As a minimum, the availability of these facilities and any special stipulations regarding their use should be added to clause H.6, "Government Furnished Property Availability to Offeror."

C7 Clause L.14, "Instructions for Two Proposals," requires the development of two compete proposals based upon alternative propulsion systems. Given the proposed restructure of the Demonstration/Validation phase into Development Phases I and II, and recognizing that no prototype hardware is to be provided until Phase II, recommend that the evaluation of alternative propulsion systems be deferred until Development Phase I or II. This will substantially reduce proposal cost preparation.

vi. *Cost Analysis Improvement Group (CAIG)*

C1 Acquisition Strategy - The CAIG is concerned of the statutory requirements of 2434 Title 10 US Code that says: "The Secretary of Defense may not approve the full-scale engineering development or the production and deployment of a major defense acquisition project unless (1) an independent estimate of the cost of the project is first submitted to (and considered by) the Secretary..." This would seem to require that a contract for what is now known as EMD (the Army is proposing that it be known as Phase III), be preceded by a formal consideration of an ICE before a contract is awarded for that phase of development, and that the process be repeated before a contract is awarded for production. The Army's proposal for "a single contract" does not seem to meet the requirement of Title 10, which is not waiverable by the Secretary of Defense.

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C2 Acquisition Strategy - The Army proposal states that there will be a competitively selected contractor." There have been reports from several sources in the Army and OSD that the Army has proposed to the four interested contractors that they form a four-way partnership to bid on a sole source basis for the single contract that will span development and production. The CAIG believes that the cost implications of a sole source contract to a four-way partnership could be very significant compared with a competitive award, and that the implications for cost growth are increased by the proposal for the award to span the entire development and production lifetime of these two major programs. It is difficult to see how there would be any incentive to minimize cost if all potential competitors are part of the same team and if they have a sole source contract for all development and production.

A Verbal answers were communicated to the CAIG on the comments for the Army proposal for streamlining the AFAS/FARV acquisition process.

**B. Lessons Learned**

<b>LESSONS LEARNED - ARMY/OSD INTERFACE ON RFP</b>
<ul style="list-style-type: none"><li>• Although Acquisition Streamlining and Reform are desired outcomes, caution is urged in light of statutory guidance that has not kept pace.</li><li>• Ensure OSD functional proponent is kept informed.</li><li>• Ensure all actions are worked through one POC.</li><li>• Meet face-to-face with OSD proponent on unresolved issues.</li></ul>



**10. OSD ROLE - ACQUISITION AND STREAMLINING**

**A. Background**

In June 1994, the Army was completing the acquisition strategy for the next generation of self-propelled artillery. There were two major issues at the Office of the Secretary of Defense(OSD) level which significantly impacted the Army's ability to initiate the cannon artillery program which would replace the latest M109-series upgrade. The two issues, Acquisition Reform and the Defense Industrial Base, greatly influenced the interaction between the Army and OSD as the acquisition strategy was floated around Washington.

**B. Battlefield "Shortfall"**

It was generally accepted at OSD that the US Army's cannon artillery was significantly behind other cannon systems on the world in terms of effective range. Our inability to reach out 40 kilometers with cannon precision of the modern battlefield was accepted as a shortfall.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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However, when discussion included the full indirect-fire capability (C3I, Precision Guided Munitions [PGMs], MLRS, logistics) the "shortfall" was less of a concern.

### **C. Acquisition Reform**

The reform of the defense acquisition process was a major litmus test of the Clinton Defense team's ability to make things happen in the Washington bureaucracy and it involved all three branches of the federal government. All programs involving the procurement of goods or services for the Department of Defense (DoD) were scrutinized for application of reform initiatives that would ease the process and further document the commitment to truly reforming the acquisition procedures. The Army's Artillery program was coming through the approval process with a requirement to be innovative and to make a good business case for acquiring the new weapon system.

Concurrent with the Acquisition Reform initiative was the continuing question of the ability of the US industrial base to respond to our country's defense needs in the face of declining defense budgets. Funding for unit readiness programs was the highest priority and research, development and new weapon system procurements were viewed by all as a declining segment of the defense market. How many of the current defense contractors would stay in the defense business was a frequent topic of discussion at senior-level meetings. The ability of the remaining base to support the two near-simultaneous Major Regional Conflicts (MRC) scenario used for budgeting was seriously questioned. The "come-as-you-are" war planning reflected the change from relying on the industrial base to impact each conflict as it develops, to a posture which demanded state-of-the-art equipment in position at the onset of a crisis and able to deter much larger force structures.

### **D. Industry Response**

Industry's response to the DoD budget reductions was to initiate multiple acquisitions and mergers. For example, Martin Marietta and Loral decided to acquire other companies in an attempt to strengthen their defense business base. General Dynamics' strategy was to "cash out" and reduce their defense business base. Other companies, such as FMC and BMY choose to merge, then downsize to strengthen their position in a declining market. OSD was directly involved in many of these decisions as the principal customer of these companies and the "expert witness" in the Justice Department analysis of the business deal.

A less formal industry response was an increased level of lobbying in the Pentagon and on Capitol Hill to create doubt on programs and/or contract awards which were not going their way. With fewer contracts anticipated, the battle for each one became even more intense than in the past. Of interest to the new artillery program was a written threat by a diesel engine manufacturer to leave the defense business if a turbine engine was a directed technology in the Artillery Accession strategy. It was with this background in capability, reform, industrial policy and mergers that the Army came forward to OSD with the AFAS/FARV Acquisition Strategy which would direct major combat vehicle contractor's to team together and accept a sole-source AFAS/FARV development program.



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### **E. Army's Teaming Concept**

A senior Army official initially floated the Army's teaming concept to OSD at an informal office discussion with a senior OSD official. There were many unanswered questions and the concept was not well received. Protection of the industrial base was offered as the major reason for the teaming. Supporting rationale included the high cost (Estimated at \$8-10 million) for each company to prepare a separate bid on the upcoming contract. For one company, which had extensive research completed on the next combat vehicle chassis, the proposal costs were too large considering their own estimate for probability of a win. They had informed the Army they may not survive if they did not win the AFAS/FARV contract.

After the Army further developed the teaming concept, including industry discussions, the AFAS/FARV strategy was presented in a formal briefing which covered some of the previous unanswered questions. Among these were team leadership, share ratios for business losses, etc. In general, the OSD staff did not support the strategy and was concerned about technical and business risks. The Liquid Propellant decision was thoroughly analyzed by the Army, yet did not have many believers at OSD. However, the Army pushed the Acquisition Reform button (new way of doing business) and began to gain a few supporters. An important point was a commitment to include OSD in the Integrated Product Teams (IPT) which would manage the program. At this point however, OSD approval of the strategy was very much in doubt.

### **F. Industry Team Brief to OSD**

Shortly after the Army briefing, the ASA(RDA) arranged for a very senior group of executives from the industry team to brief the Acting Under Secretary of Defense for Acquisition and Technology (USD) (A&T). This briefing, given by the president of United Defense, L.P., was pivotal in obtaining OSD approval of the strategy. With the president of Teledyne Continental, the president of General Dynamics, and the Senior Vice President of Martin Marietta all nodding their heads in agreement, the UDLP president briefed the business case and conditions for the new artillery program. They agreed to work together on this major new weapon system of systems and assured OSD the teaming arrangement was acceptable. Workshares were not finalized at that point, but were to be in place in time to meet the Army's schedule. After further discussions between senior Army and OSD officials the strategy was approved. Without the industry briefing, it is doubtful if OSD would have ever approved the AFAS/FARV strategy. The sole source situation remained a concern and the USD (A&T) directed the Army to develop a plan to reduce the risk to the government in negotiating the contract. The Army's Independent Government Cost Estimate (IGCE) plan was accepted as risk mitigation. A separate technology risk plan was also briefed to OSD before full approval was obtained.

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**NOTES**

**LESSONS LEARNED - OSD ROLE AND STREAMLINING**

- Service really must convince OSD of value of non-competitive awards.
- Industry may need to weigh in to preserve their interests.
- There is a great deal of pressure on Service and OSD from special interest groups and bureaucracies.

**11. FORMAL RELEASE OF REQUEST FOR PROPOSAL**

**A. OSD Verbal Approval**

*i. July 1994 RFP Release*

The Army received a verbal approval to release the RFP in early July 1994 from R. Noel Longuemare, Principal Deputy Under Secretary of Defense (Acquisition and Technology). On 18 July 1994, the US Army Armament Research, Development and Engineering Center (ARDEC) issued solicitation number DAAA21-94-R-0060, Phase I and II Development for AFAS/FARV, as a sole source to United Defense Limited Partnership. The Executive summary of the RFP called to the attention of the contractor the change to Army strategy from a competitive procurement to a non-competitive approach.

*ii. Partnering and Teamwork*

The Government, in the spirit of Total Quality Management, proposed developing an IPD approach in managing the acquisition, using partnering and teamwork to forge a long-term relationship. The teaming began during the proposal preparation for Phase I and II which occurred in the Contract Definition effort performed as a result of Solicitation DAAA21-94-R-0054, Contract Definition Tasks, for AFAS/FARV development. The Army wanted to craft an approach that reflected a fitting Industry and Government view of the best balance of performance, schedule, and cost, in a project that strives to achieve continuous improvement at each stage of development. The effort would strive to draw on each part's strengths so as to achieve, together, a quality contract outcome for the first time, within budget, and on schedule.

*iii. Single Development Effort*

Also, in the spirit of streamlining and acquisition reform, the approach called for a single development effort with periodic performance-oriented in-process reviews culminating in an award of a Low-Rate Initial Production (LRIP) contract. Through application of the principles of concurrent engineering, continuous evaluation, total quality management, and continuous improvement, the Government sought to demonstrate throughout the development cycle that it knew what the risks were, and had an abatement plan to mitigate the risks. Continuous

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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evaluation, improvement, and verification at each stage of the system engineering process prior to committing to the next stage was to be performed. The Army predicted the development cycle to consist of three phases.

iv. *Phase I - Simulation and Component Maturation*

This is a 26-month design requirements development and validation effort with the objective of synthesizing the AFAS/FARV requirements to design requirements for the Field Artillery System. Simulations, models, emulators, and component/subsystem experimentation and test are employed to validate the system design. Through development and integration of individual component/subsystem behavioral and performance models and simulations, the Army will conduct trades on, design of, and demonstration of the system in a virtual environment in order to validate that the system's design will meet the user's operational requirements.

v. *Phase II - Prototype Fabrication and Demonstration*

This is a 34-month subsystem and prototype integration and initial user assessment effort with the objective of validating that the operational requirements can be achieved through critical subsystem and limited prototype development and user testing. During this stage the Army expects critical subsystems such as the RLPG, the propulsion system, the vehicle electronic architecture, the soldier-machine interface, and other, offeror-identified, critical items to undergo extensive component and subsystem development testing prior to integrating them into a prototype for user assessment. The focus of these efforts is to reduce performance and integration risk and ensure a successful prototype demonstration.

vi. *Phase III - Full system Development and Pre-Production*

This is a 36-month development effort with the objective of validating the system through Government technical and operational evaluation of full-up prototypes and establishing a pilot manufacturing line in preparation for LRIP. Long-lead item requirements will be established prior to initiating Phase III.

The common thread throughout all phases of the development is the establishment and maintenance of an integrated hardware-software development and validation capability, consisting of component and subsystems behavioral and design models and simulations, systems integration laboratory(s), and interactive access to the Army's Battle Labs.

vii. *Constraints Removed*

The Army purposely avoided technical "How-To's," detailed schedule requirements, and imposition of Military Specifications and Standards that may hinder or constrain the contractor's ability to craft a best value program. Recognizing that it may not be feasible to meet all objective system requirements early in development, the contractor is given the latitude to propose less than the objective system performance during Phase I and II of the development cycle. The contractor makes trades between the objectives and thresholds identified in the AFAS/FARV

**Additional Lessons Learned, Updating, and Notes for Crusader**

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System Specifications to achieve the best value technical solution. There are, however, mandatory requirements, referred to as Phase II "success criteria," that represent essential performance levels to support a favorable decision to transition to Phase III.

The contractor's challenge is to take the guidance contained in the solicitation and prepare a proposal, with associated SOW, IMP, IMS, and CDRL, which articulates how a systems perspective will be maintained at all levels and in all processes. In the proposal, the Army expects to see a detailed description of how the contractor's system will meet or exceed the Army's expectations, the processes that will be used for management and continuous improvement evaluation, and the leadership and teamwork initiatives that will be instituted to remove barriers and permit individuals working the project to achieve the desired outcome--the world's best Field Artillery System.

### *viii. Information Flow*

Because information flow is a key element of success, the PM initiated a data exchange with industry and created an Electronic Library for contractor access to available technical documentation. The library documents the technologies developed during the CED phase of the AFAS/FARV programs. However, the Army also required the contractor to provide a Contractor Integrated Technical Information Service (CITIS), including on-line access to project technical, cost, and management information, electronic mail, and video-teleconferencing. The contractor was also required to define and install the service at selected Government sites required to support the project, including hardware and software not already available. The CITIS will permit IPT members to achieve, to the maximum, a paperless environment and an Industry-Government team that is virtually collocated.

### *ix. Proposed Contractor SOW*

The period of performance was not to exceed 60 months. The Government's technical performance for the AFAS/FARV was delineated in system Performance Specifications included as attachments, and in a performance-oriented Example Statement of Work (ESOW). The contractor is required to develop and propose his approach to meeting these requirements by submitting, in addition to traditional proposal information, a proposed contract SOW, and a detailed Integrated Master Plan and Integrated Master Schedule.

The contract strategy for future phases of the project allows for contracting sole source from the Development Phase I and II contractor for Phase III and LRIP. The Government will consider procuring a production technical data package as part of the LRIP contract to provide for the possibility of competitive procurements during the Production and Deployment phase.

## **B. The Government's Statement of Work**

The SOW in DAAA21-94-R-0054, included three tasks:



## **Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

### *i. Task 1 - Requirements Analysis*

Prepare a proposal to conduct a requirements analysis of the AFAS/FARV Operational Requirements Documents (ORD) and the draft AFAS/FARV system specifications. Included was the contractors' proposal for component maturation plans, with emphasis on his proposed Phase I and II activities.

### *ii. Task 2 - Engine Analysis*

Perform an analysis with the intent of selecting a specific turbine or a specific diesel engine based propulsion system for your AFAS/FARV concepts. Each propulsion system evaluation shall include, as a minimum, the data required by attachment 13 of the AFAS/FARV RFP (94-R-0060). The propulsion systems to be considered shall include those which will provide the AFAS/FARV weapon system with the mobility performance required by the AFAS/FARV ORD and the draft AFAS/FARV specifications. The analysis shall be thorough enough to allow for the selection of one turbine based concept and one diesel based concept using a best value for the for the AFAS/FARV weapon system approach. The analysis shall then be completed by comparing the one turbine based propulsion system concept and the one diesel based propulsion system concept and selecting the one propulsion system concept which is considered the best value for the contractor's AFAS/FARV vehicle concept. The one best value concept is to then be proposed as the contractor's propulsion system for his AFAS/FARV weapon system.

At the completion of the selection process, the contractor shall present his propulsion system choice with the detailed rationale for his selection for Government review. The rationale shall include detailed trade-off analyses and rationale for selection of the one best particular configuration. In addition to the detailed rationale, the contractor shall brief his selection and the results of his analyses to the Government Propulsion System Selection Review Committee. These briefings shall include the process used to select the specific turbine and diesel based propulsion system and shall conclude with the rationale for selection of the particular (turbine or diesel based) propulsion system for the AFAS/FARV weapon system.

The results of Task 2 shall be used to generate the Development Phase I and II proposal (Task 3).

### *iii. Task 3 - Phases I and II Development*

The contractor shall prepare and submit a proposal for the AFAS/FARV Phase I/II Development in accordance with the instructions included in Attachment 1. The contractor shall define and use a joint contractor/Government development, review and refinement process for the performance of this task.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**C. Lessons Learned**

**LESSONS LEARNED - FORMAL RELEASE OF RFP**

- The best approach was a Sole-Source Cost plus Incentive Fee with Award provision contract.
- The proposal becomes the statement of work and contract.
- The majority of constraints were taken out of the RFP and resulted in a better proposal and contract.

**12. CRUSADER CRESTS**

On 10 November 1994, MG John A. Dubia, Commanding General, U.S. Army Field Artillery Center and Commandant, U.S. Army Field Artillery School announced the official name of the AFAS/FARV system as "Crusader," the future 155mm self-propelled Advanced Field Artillery System.

**A. Official Crest**



**Additional Lessons Learned, Updating, and Notes for Crusader**

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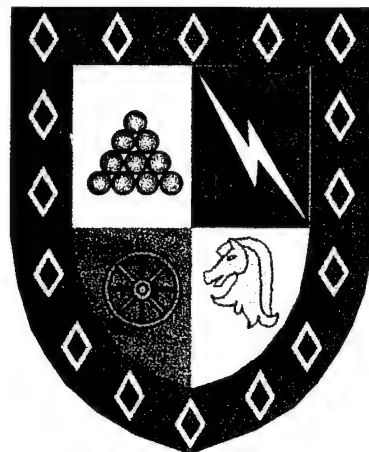
**NOTES**

### *i. Symbology*

- Red Lion is Richard The Lion-Hearted, King of Battle
  - Gray Helmet is 14th Century-Style Crusader's Helmet
  - Yellow Cannons are "Supporters"
  - Silver Capes with Red Tips are Customary of Ancient Warriors
  - Shield is Traditionally Shaped
- 
- Green Outside Thick Borders with Ancient Symbols (Diamonds)
  - Chain Mail for Survivability
  - Cannon Balls for 10 Rounds/minute Rate of Fire
  - White Background for Silver Metal (Bullet)
  - Yellow Lightening Bolt for Digitized Communications and Speed
  - Red Background for Artillery
  - Brown Caisson Wheel for Sustainability
  - Blue Background for Infantry
  - Horse represents Horse Artillery and Mobility
  - Yellow Background for Armor/Cavalry

### **B. Crest for Briefings and Small Applications**

## CRUSADER



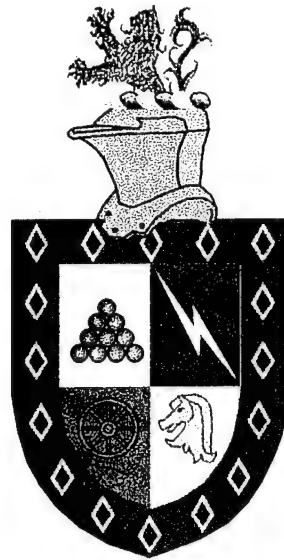
**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

C. Crests for Cups, Hats, etc.



13. OSD ACQUISITION DECISION MEMORANDUM FOR AFAS/FARV

A. November 1994 DAB Guidance

The Honorable Noel Longuemare, the Principal Deputy Under Secretary of Defense (Acquisition and Technology) sent a 4 Jan 95 memorandum to the Army Acquisition Executive, SUBJECT: Acquisition Decision Memorandum for Advanced Field Artillery System/Future Armored Resupply Vehicle (AFAS/FARV). The memorandum was guidance from the results of the 15 November 1994 OSD Defense Acquisition Board Milestone I review of the AFAS/FARV. The memorandum approved the following:

i. *Dem/Val as Single Project*

The Army's request for AFAS/FARV to proceed into Dem/Val as a single project, and authorization to order long lead items for EMD prototype prior to Milestone II, contingent upon delivery and successful initial testing of Dem/Val components and prototypes, were approved.

ii. *Milestone II Exit Criteria*

The Army's Milestone II Exit Criteria as presented at the DAB was approved. See the exit criteria table under AFAS/FARV MS II Exit Criteria on page I-71.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

### *iii. Unit Cost Control Project*

The Army was required to present its unit cost control plan, including appropriate trade-off strategies and the method for setting a realistic cost target, to the PDUSD (A&T) within the next 30 days. It was also to present its view on cooperative opportunities for joint Unicharge development and its report on diesel versus turbine engine decision and rationale when that decision is reached.

### *iv. PEO IPR - Accuracy Study*

The Army was also required to report immediately following the PEO IPR on the results of its comprehensive study on accuracy (including reproducibility and predictability), as well as recommend a relevant exit criterion. The Army had funded the current budget shortfalls except the Unicharge project, but had committed to fund the shortfall in the FY 97 mini-POM. The Army was also required to conduct AFAS excursions of the Panzer-Howitzer 2000 testing as stated in the Acquisition Strategy Report. Also, the Army shall plan for a Milestone II DAB, or equivalent review, incorporating as many acquisition reform and streamlining measures as practical. By December 1995, the Army was to submit an Operational Analysis that compares the liquid propellant AFAS with the Unicharge AFAS.

### *v. Senior Level Integrated Product Team Coordinating Council (SLICC)*

The Army shall form a Senior Level Integrated Product Team Coordinating Council (SLICC) responsible for communication, problem resolution, project documentation (e.g., the Integrated Project Assessment), and project oversight as briefed. The PDUSD (A&T) planned to personally monitor the SLICC.

### *vi. AFAS/FARV Acquisition Project Baseline*

The AFAS/FARV Acquisition Project Baseline is shown in the table below:

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

EVENT	MS I/II OBJECTIVE	THRESHOLD	CONTRACT SPECS
OSD Approval	Jun 93	Dec 93	
Milestone I ASARC	Oct 94	Apr 95	
Milestone I DAB Review	Nov 94	May 95	
Devel Phase I/II Contract Award	Jun 95	Dec 95	Oct 99
First Prototype Delivered	Oct 99	Apr 00	
Early User Test Start	Oct 99	Apr 00	
Early User Test Complete	Jan 00	Jul 00	
DAB IPR	Apr 00	Oct 00	
Phase III Contract Award	Apr 00	Oct 00	
Critical Design Review	Jun 00	Dec 00	
First Pre-Production Deliver	Apr 02	Oct 02	Apr 02
Pre-Production Qualification Test Start	Apr 02	Oct 02	
Pre-Production Qualification Test Complete	Jun 03	Jan 04	
LRIP IPR	Aug 03	Feb 04	
LRIP Contract Award	Oct 03	Apr 04	
LRIP First Delivery	Oct 04	Apr 04	Oct 04
IOT&E Start	Jan 05	Jul 05	
IOT&E Complete	Apr 05	Oct 05	
First Unit Equipped	Jul 05	Jan 06	
Organic Support Capability	Sep 05	Mar 06	
Milestone III DAB Review	Oct 05	Apr 06	
Full Rate Production Contract Award	Oct 05	Apr 06	
Service Depot Support	Dec 06	Jun 07	
First Full Rate Production Delivery	Feb 07	Aug 07	Feb 07

### vii. AFAS/FARV MS II Exit Criteria

ACTION	METHOD	TIME
Demonstrate the Ability To:	Deliver High Volume Fires and Thermal Management on either a weapons hardstand or prototype by conducting four 15 round fire missions at a rate of no less than 6 rounds per .....	1 Minute
	and simulating 10 rounds per minute for .....	3 Minutes
Demonstrate the Ability To:	On either a weapons hardstand or prototype, control the Liquid Propellant Regenerative Process by firing four 4 round Multiple Round Simultaneous Impact (MRSI) missions with all rounds from each mission impacting within .....	8 Seconds
Perform:	A Survivability Move of at least 750 meters in ..... and,	125 Seconds
Emplace:	The AFAS Howitzer and achieve a ballistic solution in .....	65 Seconds
Upload:	The FARV with 100 complete rounds (Projectile, Propellant and Fuze), using 2 projectile types, in .....	70 Minutes
Demonstrate:	Docking and transfer of 40 complete rounds (Projectile, Propellant and Fuze) FARV to AFAS and undock in .....	13 Minutes

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**14. ESTABLISHING THE CRUSADER SENIOR LEVEL INTEGRATED PRODUCT TEAM COORDINATING COUNCIL (SLICC)**

**A. SLICC Memorandum**

A memorandum, SUBJECT: Senior Level Integrated Product Team Coordinating Council (SLICC) for the Advanced Field Artillery System/Future Armored Resupply Vehicle (AFAS/FARV), was sent throughout the Army and OSD to all requisite Senior Directors, Commanders, Deputies, and the Commandant, Field Artillery School on 19 January 1995 by Mr. Dale G. Adams, PEO FAS. In order to expeditiously form the SLICC, the memorandum requested each addressee to submit to the office of FAS the name of a Colonel/GS-15 representative not later than 15 February 1995.

The memorandum stated that each representative would be expected to perform SLICC duties which would require TDY travel to the program office and contractor locations. The appointment was to remain in effect as long as the individual was assigned to his/her respective Agency. A SLICC concept briefing for the designees was to be scheduled upon receipt of the requested information.

**B. SLICC Meeting and Concept Briefing**

Mr. Wes Beal, Office of the Project Manager (OPM) Crusader was selected as the PEO's POC for the SLICC concept and implementation. On 22 March 1995, Mr. Beal held three separate briefings for 31 (of 38 total) SLICC members in the Office of Assistant Secretary of the Army, Research, Development and Acquisition [OASA(RDA)] conference room, the Pentagon. The members were from throughout OSD, Joint Chiefs of Staff (JCS), Army Secretariat, Army Staff (ARSTAF), and Army requirements/acquisition communities. Each briefing was introduced as a concept brief and an Integrated Product Team (IPT) meeting where discussions and input from the representatives were encouraged. Program specific issues were not on the agenda since the purpose was to discuss the SLICC background, plans, and proposed operating procedures.

Mr. Cris Newborn from the office of the ASA(RDA) assisted Mr. Beal in the briefing using the charts shown below:

WHAT?
<ul style="list-style-type: none"><li>• Continuous Oversight Responsibility</li><li>• Chaired by PEO FAS</li><li>• Two Way communication - Throughout OSD and Army</li><li>• SLICC will Remain Abreast of Program Issues, and Assist in Development of Solutions</li><li>• Produce Integrated Program Assessment for MS II</li></ul>

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### WHO?

- PEO Chaired
- OSD and Army Staff
- PM Crusader Division and IPT Representation

### WHEN?

- Meet at Least Annually
- Continuous Open Lines of Communications through PM Crusader Systems Engineering Division
- Continuous Information Interface through Electronic Means

### WHERE?

- Based on Program Requirements
- Funding Limitations
- Use Electrons Maximum Extent Practical

### OVERSIGHT TODAY

- Army/OSD Participation Limited
- Primary Contact with PM Office when in Pentagon
- Information Received is "Abbreviated"

#### IN SHORT:

You Only get a Selective Acquisition Report (SAR)

### COMPARISON MS II with SLICC

- Army & OSD Work Together to Provide Oversight
- Formal, SLICC Program Reviews
- Proposed CITIS Linkage
- Frequent Contract with PM Personnel

#### BOTTOM LINE:

Better Information/Oversight

### PROGRAM SCHEDULE

See Section 7, page I-49 for the Program Schedule

### SLICC PROCESS

- Annual Review
- E-Mail by All Reps and Sys Eng SLICC Office
- Contractor Integrated Technical Information System (CITIS) - FY 96



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## C. Lessons Learned

### LESSONS LEARNED - ESTABLISHING THE SLICC

- Value of SLICC is to help PM in communication and problem solving resolution.
- Funding for travel must be addressed for SLICC members.
- SLICC members must have e-mail/Internet access for responsive communication.
- CITIS linkage was limited to the PEO POC for the SLICC.

## 15. AFAS ACCURACY ERROR BUDGET STUDY

### A. Purpose

The purpose of the AFAS Error Budget Study was to develop the best analytical approach and requisite analytical tools to provide answers to AFAS accuracy questions and to characterize technical trade-offs so that the resulting weapon could meet its accuracy requirements. This involved developing and executing a plan to establish a continuing rationale for identifying AFAS system elements which contribute most significantly to the AFAS delivery accuracy. Using appropriately modified effectiveness models, the sensitivity of AFAS target effectiveness to variations in the magnitude of component error sources would be determined. The Study Team recognized the most important error components and the best concepts for reducing effects. This accuracy study was an early PM initiative to reduce risk prior to Dem/Val, since no conventional means of obtaining required accuracy at AFAS required ranges existed. It was a parallel effort with the RLPG Advanced Technology Demonstrator program, and, as the hardware ATD program sought to advance the state of the art in employing Regenerative Liquid Propellant, the Accuracy Study sought advances in achieving long range accuracy advances.

### B. Approach

To meet the objectives, a team of analysts and engineers was established involving the following organizations and areas of specialization:

ORGANIZATION	AREA OF CONCENTRATION
AMSAA	AFAS accuracy model development and error analyses
ARDEC Firing Tables Branch	Error budget analyses and data base
ARDEC Battlefield Management Branch	Accuracy improvement technologies and risk assessments
ARDEC Analytical Evaluation Branch	Target effects analyses

The plan consisted of two main activities: First was the development of an AFAS model suite consisting of 1) an Error Budget Model capable of providing accurate assessments of overall delivery errors and determining the component contributions to those errors, and, 2) an AFAS Terminal Effectiveness Model; the second activity consisted of a series of analyses which:

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- evaluates potential techniques and technologies to improve delivery accuracy
- determines the sensitivity of overall delivery accuracy to component and subsystem errors
- develops meaningful performance specifications for accuracy related components
- establishes testing requirements to ensure meeting requirements, and
- assesses cost, schedule and technical risks involved.

### **C. AFAS Model Suite Development**

The subsystem error models are the methodology and data bases required to identify and quantify all on- and off-carriage error sources at the component level and contains submodels that will generate subsystem error estimates from the component error sources. Both component and subsystem error distributions will be characterized by their mean and one sigma values. The subsystem error estimates provide the impute to the AFAS system error model.

The system error model takes various subsystem components and develops an overall system accuracy estimate, achieved with a new AFAS Monte Carlo Accuracy Model. This will evaluate AFAS specific accuracy issues and provide input into the AFAS Terminal Effectiveness Model. Because of the unique capabilities of AFAS, such as Multiple Round Simultaneous Impact (MRSI) missions, a Monte Carlo approach is necessary. The AFAS Terminal Effectiveness Model is an improved version developed from the Smart Munitions Analysis Code (SMAC) whose developer and proponent is the ARDEC Analytical Evaluation Branch.

The joint capability of the AFAS Error Budget Model and Terminal Effectiveness model will provide the ability to address the effectiveness payoff and optimize the suite of accuracy and precision enhancement techniques, for both on- and off-carriage applications, when AFAS is fielded.

### **D. Early Analysis Results**

Early analyses were performed and reported to PM AFAS as Interim Results. These analyses included use of the predicted fire delivery technique using the current MET message, muzzle velocity variations from standard, weapon location, and target location with an accurate computational procedure to obtain first round fire for effect. The Paladin baseline considered two hour MET message, one velocimeter per battery, and bag charges. The AFAS baseline considered one half-hour MET message, one velocimeter per tube, and 15 zone LP gun. Accuracy data were generated for the M483A1 Dual Purpose Improved Conventional Munition (DPICM) Projectile, the M549A1 Rocket Assisted Projectile (RAP), and the M864 Baseburn Projectile, in the latter case using the M577 fuze. After these analyses, the error budget for

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AFAS was refined and some methodology changes were made. These changes included the development of the three component accuracy model and a breakout of errors specific to MRSI missions.

From the interim study, the importance of timely MET information, and the need for a Projectile Tracking System (PTS) was determined. By November, 1992, a synopsis of ARDEC's design analysis and tradeoffs for the PTS had been delivered to PM AFAS, and is discussed below. According to Larry Yung of the Crusader PM Office, Muzzle Velocity and obtaining timely accurate MET data were the most crucial variables. Methods exist to determine muzzle velocity, so emphasis was given to the Projectile Tracking System (PTS) as a means of determining the MET information, and the adaptation of an interferometric algorithm derived from astronomy to process resultant data (e.g., simulator-based testing at Yuma Proving Grounds using interferometric techniques alone increased accuracy by a factor of three).

### **E. AFAS Projectile Tracking System**

A November 1992 document titled *Design Analysis and Tradeoffs for the AFAS Projectile Tracking System* was prepared by Mr. Charles Seitz of the ARDEC Fire Support Armaments Center Fire Control Division R&D Branch provided PM AFAS with the next plateau for achieving the desired accuracy of the system. In the background section of the synopsis, Mr. Seitz asserts that the AFAS mission profile implies the need for a projectile tracking device which will allow each howitzer to measure the impact of its projectiles and autonomously adjust its fires onto targets 40 to 50 km away. He suggests that current knowledge of upper wind effects can be obtained by tracking projectile deviations from an nominal computed trajectory allowing corrections of subsequent rounds. Newly acquired MET data can then be transferred into the computations of trajectories for other targets...[combined with] MET data collected from many individual howitzers [and] measurements from other sensors to provide an overall atmospheric profile of the battlefield. ARDEC was requested to transition a Grumman Corporation steerable tank projectile system into the AFAS requirement to assess its potential for enhancement of long range firing accuracy. This system is historically relevant because it provided a baseline design for AFAS.

### **F. AFAS PTS Operational Requirements**

Differences between tank and artillery requirements included the following:

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TANK SYSTEM	ARTILLERY SYSTEM
Direct fire to 5 km, with comm links tied to forward looking infra-red radar (FLIR) and optical sights	Long range performance despite rain or cloud cover
Tank system designed for projectile guidance	No artillery guidance requirement, so the AFAS system is simplified by removing the thruster control functions
Custom tank projectile	Logistical considerations drive need to retrofit onto existing artillery rounds

Challenge remained in the electronics packaging task. The housing must protect sensitive microwave components from gun blast, and remain attached to the projectile for the duration of the flight.

To establish the PTS design requirements the principal elements of the AFAS mission profile were examined. Requirements and supporting rationale are summarized as follows:

AFAS DESIGN REQUIREMENT	RATIONALE/DETAIL
Operational Range - at least 27 km slant distance	Tracking to max. ordinate is essential to measure the effect of highest altitude winds. Rain occurs during the first 6 km of altitude causing signal attenuation for about 10 km of slant range. A tracking geometry figure is provided below to show altitude and slant factors.
Tracking Accuracy - 0.5 milliradians	Paramount design consideration, derived from a family of trajectories include. standard and non-std. MET trajectories. Tracking angles were calculated from the typical deviations in azimuth and elevation which are caused by nonstandard conditions. The 94 GHz transponder system easily achieved submilliradian accuracy during Calverton, L.I. field testing.
Ranging Accuracy - plus or minus 5 meters (slant distance)	Tank digital electronics easily achieved desired accuracy, so were retained. Better range accuracy will be achieved by an averaging algorithm.
Rain performance - 5 mm/hr.	This criteria delivers usable performance 99% of the time based upon a world-wide average.

The study also forecasted communication link requirements, transmitter power, receiver noise, antenna considerations (tracker and projectile), and path loss, along with data and determinations regarding each factor.

A spreadsheet based trade off analysis of PTS configurations operating within the 94 and 35 GHz window bands concluded that the existing 94 GHz equipment could not be realistically



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modified to meet AFAS requirements with the desired design margin. This assessment concluded that a 35 GHz PTS exhibits characteristics that are suited to the AFAS mission. Its design analysis substantiates it as a credible configuration which will meet the projectile tracking needs of AFAS with an adequate design safety margin.

### G. Lessons Learned

#### LESSONS LEARNED - ERROR BUDGET STUDY

- The investment by the PM and the results delivered by the ARDEC/AMSAA community really show that it is the Government's job to develop required tools and techniques. Contractors are not given to taking excursions and making investments in advancing the state of the art in this type of technical advance, e.g., neither predecessor, General Electric, nor Lockheed/Martin had invested heavily in this type of R&D.
- If the Crusader program assumed that the contractor would meet the performance requirement, the PM would be processing waivers later in the program, instead of having the lowered risk which results from this type of investment.

## 16. PROPULSION SYSTEM SELECTION

### A. Summary

By the end of January, 1995, Crusader prime contractor UDLP had reviewed the findings of their government-facilitated source selection board, and had made several key decisions. In the January briefing presented to the Army Acquisition Executive and other key personnel, the agenda consisted of an overview of the Requirements and Specifications that applied, the Selection Process by which decisions were reached, Implementation of that Process, and the rationale surrounding their Best Value Selection. The decision to select the Perkins Engines Limited's CV12 Engine and the Martin Marietta-proposed HMPT 1250-EC Transmission was briefed, followed by a public release of the information, which drew little comment from interested parties and the defense press. The following paragraphs highlight that briefing.

### B. Requirements and Specifications

The Operational Requirements Documents, or ORDs, for Crusader detail a self-propelled 155mm howitzer that has improved lethality, survivability, and sufficient mobility and agility to keep up with the supported maneuver force. Specifically, Crusader will be capable of:

- Sustained cross country speed of 39-48 kph; 67-78 kph on level highway
- Moving 750m within 90 seconds
- A Cruising range of at least 405-450 Km at 47 kph
- Reverse speed of 20-25 kph on a level, hard surface

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- Full stop from maximum speed at a rate of at least  $5\text{m/sec}^2$
- Reduction of power for 6 hours, then be operational in 45 seconds.

Selected Propulsion requirements were detailed in the presentation, to include the Mission Equipment Power, Mobility Performance (to include cross country speed, fuel economy, desired width, towing parameters, and steering torque), Performance (environment, slopes, long term idle), Reliability and Maintainability (RAM), MANPRINT, and Testability and Support Equipment.

United Defense's Request for Proposal to industry was characterized as follows:

TECHNICAL	COST	MANAGEMENT
Design to Product Development Specification	Dem/Val	Program Execution
Deliver 9 Sets of Hardware	DTUPC	Program Organization
Meet RAM Goals	P3I Development Cost (for 17% Vehicle wt. growth)	Personnel and Program Admin.
MANPRINT Test Support	O & S (Selected Elements)	Cost/Schedule Control System Program Cost Control Cost Management

### C. The Selection Process

A three-tier Source Selection process was described by UDLP, with the Source Selection Authority (SSA), a Source Selection Advisory Council (SSAC), and Source Selection Evaluation Boards (SSEBs) as the operational components. Responsibilities were detailed as follows, emulating the government process:

SSA	SSAC	SSEB
Makes Selection Decision	Prepare Comparative Analysis of SSEB Results	Perform Technical Evaluations
Approves Source Selection Plan	Apply Numerical Weights to Criteria	Prepare Evaluation Reports
Establishes Evaluation Group Structure	Evaluate Cost/Management Information	Brief SSAC

Guidance to the SSEBs charged them with scoring 52 factors, assessing Propulsion System Automotive Performance (Speed on Grade Curve, Steering and Braking, Cooling Analysis), Propulsion System Weight (Power Pack, including engine, transmission, cooling, final drives), and Fuel Storage (Battle Field Day or Range); Layout of Ground Hop Power Pack (Model and Space Claim), and the Technical Risk, focusing on the state of the technology and design difficulty.

The Technical Evaluation Process commenced with delivery of the Technical Volumes to respective SSEBs, whose membership assessed the proposals against the 52 scored factors, then

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presented hardcopy and a briefing of their results/rationale to the SSAC. The SSAC reviewed this data for consistency, comparing engine to engine, transmission to transmission, power pack to power pack, and diesel power pack to turbine power pack. The SSAC then established the Integrated Technical Ranking.

The SSAC was operative in assessing Cost Proposals, reviewing each for completeness, assessing probable cost and realism, then ranking the offerors. Management Proposals were also the province of the SSAC, whose members reviewed the proposals for Organization and Cost Management approach. A combined team from the SSEBs and SSAC visited Engine vendors, scoring each on Program Execution, Organization, Personnel and Program Administration, their Cost/Schedule Control System and Program Cost Control. The SSAC then performed Management Rankings.

Characteristics of this process were briefed to include: assessments based on comparative analysis; quantitative rankings used only as guides; strengths, weaknesses and risks considered for each power pack combination; consistency checks were used against stated criteria, and; weighted results were used in determining best value in technical, cost and management domains.

### **D. Implementation of the Selection Process**

A Draft Solicitation was released by UDLP on 22 September 1994, with 179 questions or comments received. On 29 September a bidders conference was held, with a Final RFP issued on 11 October, 1994. All questions and comments were answered. By 11 November, 12 proposals had been received, to include nine from six engine manufacturers and three proposals from two transmission manufacturers. On-site reviews were conducted at engine manufacturers between 1 and 15 December. Bidders lists for Engines and Transmissions were as follows:

<b>ENGINES</b>	<b>TRANSMISSIONS</b>
LHTEC, Allison Engine & Allied Signal*	Allison Transmission Div., GM*
Caterpillar Inc.	David Brown Vehicle Transmission
Cummins Engine Company*	Martin Marietta Defense Systems*
Detroit Diesel Corporation	Kaman Electromagnetics Corp.
JPO, GE & Allied Signal*	Zahnradfabrik Renk AG
MTU Friedrichshafen	ZF Industries
Perkins*	
Rotary Power International, Inc.	
Teledyne Vehicle Systems*	

Note: \* denotes those companies submitting proposals

UDLP's briefing provided an overview of each of the proposed products. The Perkins CV12 Engine is a V12, 1300 Hp water-cooled diesel, weighing 4723 lb., and is a production engine used in the British Challenger and Jordanian Khalid tanks. Full Production would occur in the US by Caterpillar, Inc. The winning transmission was the Martin Marietta HMPT 1250-

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EC, described as hydromechanical, infinitely variable, weighing 3350 lb., with full authority digital electronic control. This transmission is a new development based on previous models, and will be developed and produced in the US.

### **E. Best Value Selection**

The briefing provided by UDLP described its rationale for selecting the Perkins/Martin combination in the following manner:

#### Technical Assessment Summary:

- Combination meets all Performance Requirements & Engine Demonstrated at Growth Horsepower
- Condor V12 engine is in Production at Required Hp (Commercial & Military applications)
- Diesel combined with Infinitely Variable Ratio Transmission Provides Superior Fuel Economy
- Transmission Reliability Significantly Increased because the vast majority of parts are not loaded during Combat Idle
- Supportability Enhanced by Perkins Worldwide Parts/Service Distribution System

#### Management Assessment Summary:

- Perkins: Experienced personnel assigned, good facility & infrastructure in place, excellent continuous improvement program in place, very cost conscious organization with worker and supplier involvement.
- Martin Marietta: Well-defined program plan, well-defined PDTs, experienced in IPD execution, tri-service validated C/SCS program.
- Cost realism was assessed; offers best technical merit at an affordable price.

UDLPs Final Evaluation Summary stressed that all vendors were rank-ordered in all areas (Tech, Cost, and Management), weightings had been applied to all rankings, and combined value of all areas was assessed, resulting in a "Selection based on Best Value for Crusader."



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**F. Lessons Learned**

**LESSONS LEARNED - PROPULSION SYSTEM SELECTION**

- A government-facilitated contractor selection process can result in a best value, defensible, no-challenge outcome for critical components of a combat vehicle system.
- Risk-avoidance factors weigh heavily in the assessments of the industry participants when technology challenges exist.
- The prime contractor selection of the propulsion system, as opposed to the Government selection, clearly places System Engineering and Integration (SE&I) responsibility with the prime. It also saves the Government acquisition process money and shortens the overall schedule.

**17. PROJECT MANAGER'S DIRECT REPRESENTATIVE (PM DIRECT REP)**

**A. PM's Concern/Concept**

*i. IPT Interface*

After lengthy discussions and fact finding concerning the Integrated Product Development (IPD) environment, COL Sheaves decided to assign a person to the United Defense plant in Minneapolis, Minnesota, and to the Martin Marietta (MM) RLPG plant in Pittsfield, Massachusetts, effective 2 Jan 95. The IPD is a new way of doing business for the Army and especially for the PM, Crusader. Requiring constant interface with the Integrated Product Teams (IPT), COL Sheaves felt that the contractors needed an on-site "Government Person" (PM Direct Rep) who would provide/react with immediate response. Also, this initiative would enhance the program's compact development schedule and would prevent large time gaps for problems, decisions, and information if the contractor was required to officially request responses as they occurred.

*ii. Stationing PM's Direct Reps*

The IPD development process relies on both the Government and the contractor to jointly proceed through development in a cooperative atmosphere. Although COL Sheaves had not previously utilized a PM Direct Rep, he wanted to ensure that for the Crusader project, and through the Government's participation, real value would be added. The stationing of the PM Direct Rep with the contractors was an excellent control measure to assist PM PDTs as they learned how to work in the IPD mode.

The PM Direct Rep for UDLP in Minneapolis, MN, Major Peter (Pete) Ostrom, was selected because of his intimate knowledge of the Crusader project and his broad background in Army acquisition. The PM Direct Rep for MM, Pittsfield, Massachusetts, Mr. Theophil (Ted)

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Kuriata, was chosen because of his intimate knowledge of the RLPG and because he was also the Armaments IPT Chief. They were given three broad missions to accomplish:

- Facilitate Government interaction to obtain concurrence on the Dem/Val technical proposal prior to submission.
- Troubleshoot the entire PDT process and repair all problems as the project progresses - "Joint Group Dynamics."
- Provide both the plant contractors and the Project Manager with a responsive communications link which keeps both informed of the other's activities.

### B. Lessons Learned

LESSONS LEARNED - PM'S DIRECT REP
<ul style="list-style-type: none"><li>• Direct PM plant reps are essential to PM mission success.</li><li>• Future IGCE teams should seek early, effective lines of communication with plant reps.</li><li>• Direct reps provides continuous contact with the prime contractor and act as the "voice" of the Project Manager.</li><li>• The direct reps ensure the integration of the Government's PDTs and provide liaison to Defense Plant Representative Office.</li></ul>



## 18. BUSINESS CLEARANCE MEMORANDUM (BCM)

### A. Procurement Contracting Officer

Mr. Jeffrey M. Boyle, the Crusader Procurement Contracting Officer (PCO), forwarded a memorandum through channels to Mr. Joseph R. Varady, Jr., the Director of Procurement Policy, Assistant Secretary of the Army for Research, Development, and Acquisition on 14 February, 1995. The subject was Individual Federal Acquisition Regulation Deviation for preparation and format of the Crusader Project Phase I & II Proposal Pre-Negotiation Objective Documentation (BCM).

#### i. *Rationale for Request*

It was estimated that using conventional pre-negotiation requirements, prior to initiating the negotiation process, would require approximately seven months to execute the Phase I & II modification. Also, by utilizing conventional methods of evaluation and documentation, by the time the Government completed its technical and pricing evaluations and established a

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negotiation position, the contractor's proposal could significantly change, causing a re-evaluation of the Government position. The use of the streamlined negotiation approach will result in a contract modification within two months from receipt of the contractor proposal.

### *ii. Streamlining Lead-time*

In an effort to streamline the lead-time associated with both the contractor submission of a comprehensive proposal for Phases I & II and Government analysis/negotiation of the same, the Government intends to:

- Use its Independent Cost Estimate as its pre-negotiation baseline/objective.
- Concurrently develop the Cost, Technical and Management sections of the Contractor's proposal which will include the Statement of Work (SOW), Integrated Master Plan (IMP), and Integrated Master Schedule (IMS), through the efforts of personnel assigned by the Prime Contractor, Procuring Contracting Office, Defense Contract Audit Agency, Administrative Contracting Offices, ARDEC Pricing Division and Integrated Product Development Teams.

### *iii. Current Federal Acquisition Regulation Requirement*

Federal Acquisition Regulation (FAR) 15.807 (a). In setting the pre-negotiation objectives, the contracting officer shall analyze the offeror's proposal, taking into account the field pricing report, if any; any audit report and technical analysis whether or not part of a field pricing report; and other pertinent data such as independent Government cost estimates and price histories.

Army Federal Acquisition Regulation Supplement (AFARS) 15.890-3 ("Content of Business Clearance") dictates the comprehensive detail required for the Pre-Negotiation Objective.

## **B. Deviation Narration**

### *i. Proposed Army Deviation*

The Army intends to use its Independent Government Cost Estimate as its Pre-Negotiation Baseline/Objective. This IGCE is to be approved by the Army Acquisition Executive (AAE) and the Defense Acquisition Executive (DAE). Prior to approval by the AAE and DAE, the IGCE will be routed through the Principal Authority for Contracting Activities (PARC) for the Head of Contracting Activities (HCA) concurrence as the Pre-Negotiation position prior to initiating negotiations. This will be done in lieu of developing a Pre-Negotiation Objective from the contractor's proposal. The IGCE format will be used in lieu of the AFARS Business Clearance format. The IGCE will establish an in-depth cost estimate with supporting analysis which mirrors the contractor's technical approach and work breakdown structure format. The IGCE was developed by a Government team established by PM Crusader.

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It includes cost analyst, engineers, and procurement and legal personnel who are utilizing historical data on all facets of the Crusader project from Concept Exploration and Definition to Component maturation as well as information derived from discussions with both prime and subcontractor representatives regarding approach.

Upon concurrence in the pre-negotiation objective, the Government team will participate in the development of the contractor's cost, technical, and management proposal through involvement in Integrated Product Development Teams (IDPT). These teams include contractor personnel and Government personnel representing the contracting office, Defense Contract Audit Agency, Contract Administrative office, ARDEC Pricing, and ARDEC and PM technical offices. The PARC and Head of the Contracting Agency (HCA) will be updated monthly, in conjunction with PEO/PM reviews, as to the status and outstanding issues during this process.

Each work breakdown structure element will be addressed during this process. The Government will document the IGCE baseline, the contractor's initial position, and any revisions to either as a result of discussions, along with the rationale for the change. Upon receipt of the contractor's completed proposal, the Government team will document to the PARC the results of the discussions, and any existing differences between the Government position and the contractor's proposal. This will be accomplished prior to concluding discussions.

The first post-negotiation memorandum will reconcile the final agreement with the original IGCE and the contractor's proposal with rationale and details sufficient to document that the price is fair and reasonable. This final agreement will be summarized and forwarded through the PARC to the HCA for approval.

### *ii. Deviation Effects*

The proposed deviation will have a positive effect on the operations of the requesting Agency and will result in a significant cost and time savings to the Department of the Army. There will be no negative impact on the contractor as a result of the deviation. In fact, the contractor may experience time and/or cost savings as a result of the reduction in lead time required for documentation and negotiation of a final settlement.

### **C. BCM Approval**

On 2 March 1995, Mr. Joseph R. Varady, Jr., Director of Procurement Policy, ASA(RDA), approved the BCM.



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**D. Lessons Learned**

LESSONS LEARNED - BCM
<ul style="list-style-type: none"><li>• BCM saves seven months of pre-negotiation requirements</li><li>• Uses IGCE as pre-negotiation baseline</li><li>• Results in significant cost and time savings for Government</li><li>• Contractor may also experience cost or time savings</li></ul>

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## **CHAPTER II**

### **CRUSADER TECHNOLOGY, CONCEPT, AND LESSONS LEARNED**

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## 19. LIQUID PROPELLANT PROGRAM

### A. Background

The D155 Liquid Propellant (LP) program was initiated in FY85 for the purpose of providing performance, cost and logistics benefits to the Army. The program objective was to demonstrate a ballistic viable 155mm gun system. Army development of regenerative gun technology was under contract with the General Electric Company in Pittsfield, Massachusetts.

The LP program successfully transitioned from the US Army Benet Research Laboratory (USABRL) to the US Army Research, Development and Engineering Center (ARDEC) in July 1989 and is currently managed by the PM for Crusader along with several other advanced technologies for insertion into the Army's next generation 155mm SPH system.

On 26 September 1991, the HQDA General Officers Steering Committee's recommendation to the Army Acquisition Executive was to select LP as the primary propellant for the next generation howitzer because LP has greater performance than other types of propellants and growth potential and is the Army's propellant of choice - but, to continue Unicharge as a backup. This milestone event was made possible by the extensive data base assembled in July 1991 by the LP Development Project office based on the requirements detailed in the Cannon Artillery Propulsion Evaluation Plan. This plan required 90 data submissions to assess propellant system performance, logistics, MANPRINT, survivability, and cost.

#### i. *Regenerative Liquid Propellant Gun (RLPG)*

The principal elements of the regenerative LP gun system are the fill system, the regenerative gun, the igniter, and the gun controller. The fill system services both the gun and igniter by providing the proper amount of propellant at the required and accurate rates. In 1991, contractual work began on the AFAS concept exploration and ATTD project to develop an RLPG, a key technology effort in a next generation artillery system, and other artillery specific technologies which will reduce risk prior to entering Development Phase.

#### ii. *Gun Demonstrations*

Subcaliber tests were ended in November 1989 when a burst of 10 rounds fired at a rate of 6 rounds per minute was demonstrated in a 30mm laboratory fixture. More than 3,000 rounds were fired from six 30mm fixtures over a five-year period. Testing supported basic concept and Interior Ballistics (IB) model development, seal design, prove out of an LP igniter, and parametric analysis of the injection orifice and damper. Scaling of ballistic parameters was verified in 125 firings with a 105mm fixture when these tests ended in March 1988.

The 155mm LP Gun #1 was first fired in July 1988 and was the world's largest caliber LP gun to be developed and fired. The gun was a single shot laboratory which required a change in hardware configuration in order to effect a change in zone. Before completing tests in September

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1990, 295 rounds were fired, demonstrating full caliber ballistic control, excellent velocity, and uniformity at zones 2, 5, 7 and 8. For example, at zone 8, a velocity of 694 m/s was demonstrated. Also, a velocity uniformity of 0.24 % SD was demonstrated in 10 consecutive shots. The same pistons, valves, and seals developed through parametric firings of the gun were later incorporated into the design of LP Gun #2. More importantly, empirical verification of the IB model was obtained. This proved scaling and allowed use of the model for design and prediction. The IB model matches empirical pressures to within 10% and empirical velocities to within 1%.

The 155mm LP Gun #2 was first fired in July 1990 and has been fired 444 times. The LP Gun #2 is a fully automated gun, designed to allow operator selection of any zone from 1 to 14.2 liters. Incorporating an LP-based ignition train, the gun is capable of sequencing through 3 rounds at 6 rounds per minute. Muzzle velocities from 390 to 940 m/s have been demonstrated, as well as a fill rate of 10 liters per second and a fill accuracy of better than 0.1 weight %. Weighing in at 8,200 pounds, the LP Gun #2 assembly weighs significantly less than the 15,300-pound LP Gun #1, despite the fact that LP Gun #1 has 37 inches of less barrel length. Under a project partially funded by GE Independent Research and Development (IR&D), the LP Gun #2 was originally scheduled for integration into a retrofitted M109 vehicle. This project, however, came to a stop due to delays caused by three equipment failures. Two of these failures, an igniter body and a static ring seal, were attributable to material fatigue.

The third failure, an incident involving 3 liters of LP in the metering device of the fill system, resulted in the loss of the fill system and much of the electronic control equipment. The incident occurred during a post firing compliance check (3 minutes after shot #99) and involved compression initiation of a 40% air, 60% LP mixture in the metering device. Air inadvertently entered the metering device by back flow through a line isolation valve. These failures resulted in an unrecoverable four-month slip in the test and evaluation program, and a stop work on the integration project. The gun resumed firing on 27 July 1991 and completed a 10-round group for velocity uniformity at minimum charge (i.e., 1.5 liters). A 0.53 % SD in muzzle velocity was achieved at an average velocity of 374 m/s.

The next incident occurred on 3 May 1994 during the firing of the Martin Marietta Defense System (MMDS) ATD-1 at the Malta Test Station, Malta, NY. ATD-1 Test Shot 30 was intended to be the first shot in a series to demonstrate a two-round burst firing at Zone 5 (6.7 Liters nominal, actual 6.84) with an optional third round. There was an unusually loud noise at the time of the gun firing, loss of connection to test cell electronics, yellow-brown smoke, and a second loud noise 10-15 minutes later. There were no injuries to personnel; but there was extensive damage to the breech assembly and the propellant handling system. The most likely causes for the failures were inadequate ignition/puddle injection and timing, injection orifice geometry, and fill valves.

This incident should not be confused with an unrelated liquid storage tank incident (explosion) which occurred during an engineering design test at elevated temperature of an Advanced Technology Demonstrator (ATD) storage tank at the Malta Test Facility on the following day.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

The RLPG #2 shot 417 incident occurred in August 1994 resulting in extensive damages, but no injuries. The majority of the root cause analysis effort was conducted from 10 August 1994 to 2 September 1994 (a test readiness review which determined the probable cause of findings and risk mitigation techniques proved sufficient to continue RLPG #2 Milestone I testing). The probable cause was either that sensitized LP captive from previous shots ignited in the LP reservoir when contacted by neat LP or that a hot spot, due to seal failure, was created in the LP reservoir due to heating or galling chip formation during fill.

### *iii. Technology Issues*

There are pressure oscillations at high frequency (50 KHz) and low energy instabilities in the combustion regions of the RLPG. The major concern associated with pressure oscillations is the transmission of a coherent impulse through the base of the projectile and an adverse impact on the reliability of sensitive projectile and fuze components.

There is no data to support concerns in the areas of wear and decoppering which may reduce the severity of barrel wear.

The propellant is moderately toxic with a systemic effect of classic nitrate poisoning, which results in a rise in methemoglobin levels and a reduction in the oxygen carrying capacity of the blood. These effects are generally reversible with or without an antidote. An LP exposure is not insidious although skin irritation will accompany an exposure.

The resupply vehicle holds many advantages for the storage and shipment of LP. Contamination avoidance and enhanced survivability are just two. However, the final package has not been designed and the impacts of this package on an insensitive munitions assessment and hazard classification are unknown. These impacts can, in the final analysis, strongly influence the logistics and cost of LP.

Based on small scale tests, including assessment of impact on indigenous plant and animal life, there is no known environmental hazard associated with LP. However, the effect of large scale spills is unknown. LP will not persist in most soil and water conditions due to its pH sensitivity, and in a variety of tests, has proven not to be a carcinogen. However, the same concerns with conventional ammonium nitrate fertilizers and their impact on potable water supplies also hold true for LP.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**B. Lessons Learned**

**LESSONS LEARNED - RLPG PROGRAM**

- Army and contractor personnel initiated the Advanced Technology Demonstrator (ATD) too soon. Based on a small set of empirical data, a false sense of security was endemic. Schedule attainment goals pushed the developers ahead, despite lingering questions about the chemistry/physics at work.
- Advantageous costs benefits remain an attractive feature for RLPG. Liquid propellant costs are currently 1/3 to 1/5 the cost of solid propellant.
- Modeling and simulation opportunities were missed in the RLPG development.
- Early criteria for test performance may have been set too high, given the numbers of variables that needed further detailed analysis.

**20. SOLID PROPELLANT PROGRAM**

**A. Bottom Line - Up Front**

The Army recognizes the risk associated with the LP/RLPG program, but remains committed to its leap-ahead potential. The higher pay-off outweighs the risk. Also, it is prudent to continue limited development of an advanced solid propellant and armament system as a back-up to the LP/RLPG. The solid propellant program provides risk mitigation and is technically achievable; however, the performance potential is lower than the LP/RLPG.

*i. 155mm Advanced Solid-Propellant Armament (ASPA) System*

The objective of this program is to have an advanced solid propellant armament ready for hand-off to the Crusader Dem/Val Contractor in FY97, if needed. The ASPA system is composed of the XM297 Cannon with integral muzzle brake, advanced bore evacuator, integral midwall cooled (IMC) tube with chrome plated bore and chamber, multi-lug slideblock breech, laser ignition system, and a Crusader gun mount. The gun mount will have a modular recoil system, advanced ballistic shield, and is liquid cooled. The ASPA system must be compatible with the Modular Artillery Charge System (MACS).

The ASPA system must also be compliant with the Joint Ballistic Working Group (JBWG) Memorandum of Understanding (MOU).

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**JBWG MOU**

- Minimum Range - 4 km @ 200 Mils Q.E. (low Angle); 6 km @ 1244 Mils Q.E. (High Angle)
- Maximum Range - 30 km Unassisted (Essential); 40 km Assisted (Desired, U.S. Essential)
- Barrel Length - 52 Calibers Maximum
- Compatibility - Must be Compatible with Existing and Developmental Projectiles that Meet the MOU (Essential); All Fielded Projectiles (Desired)
- Barrel Life - 2,000 EFC (Essential); 2,500 EFC (Desired)
- Ballistic Similitude JBWG MOU Compliant 39 Cal Similitude (Essential); MOU Compliant 39 Cal Match (Desired)

ii. *ASPA System Program Accomplishments*

**FY 93**

- Adapted XM291 Slideblock breech for use with artillery munitions
- Conducted component testing of critical breech, tube and LASER components
- Characterized laser ignition of XM230 Unicharges and current bag propellant charges
- Fabricated first generation monoblock and integral midwall cooled (IMC) tube assemblies
- Conducted initial verification tests of (monoblock) Cannon SN1 (82 rounds fired)

**FY 94**

- Initiated design of the bolt-in/bolt-out XM194 gun mount for integration into Paladin
- Completed 80 round mount recoil module proof test
- Fabricated the first generation IMC Cannon (SN2)
- Verified integral muzzle brake efficiency
- Continued design and testing of the laser ignition system

**FY 95**

- Completed 209 round mount recoil module proof tests
- Completed 165 round proof test of IMC cannon SN2
- Demonstrated laser ignition firings from the M109A6 Paladin
- Completed 515 round pre-fatigue test of cannon SN2
- Completed fabrication of the second generation monoblock and IMC cannons (SN3 and SN4)
- Initiated hydraulic fatigue testing of tube SN2
- Initiated engineering design test phase 7 of tube SN3
- Initiated second 583 round pre-fatigue test of tube SN4
- Initiated ammunition handling system concept studies
- Completed the initial Paladin integration feasibility study

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

iii. *Modular Artillery Charge System (MACS)*

The MACS consists of two types of solid propellant charges designed for 155mm artillery for Paladin, M198 towed, and as a backup for Crusader. The XM232 uses M30A1 granular, triple base propellant, center core ignitor with end pads, and a right circular cylinder combustible case. The XM231 is a stand alone bottom charge, provides Zone 1 and 2 performance for minimum range, and is derived from XM215 and XM230 technologies using M1 propellant.

Both charges (MACS) feature bi-directional ignition using percussion primer or laser ignition; decoppering, flash and tube wear additives are embedded (XM232 only); are compatible with the insensitive munitions standard and with manual and automatic loading systems; meets the JBWG interoperability requirements; and has modified PA 103 container packaging (5 increments) for the XM232 and PA 161E for XM231. MACS evolved from the Unicharge (XM230) when Zones 1 and 2 of the Unicharge proved unusable.

iv. *XM230 Unicharge Program Accomplishments*

FY 93
<ul style="list-style-type: none"><li>• U.S. Army Training and Doctrine Command (TRADOC) approved ORD</li><li>• IM tests passed - shaped charge jet and sympathetic detonation</li><li>• Packaging improvement and increment separators</li></ul>
FY 94
<ul style="list-style-type: none"><li>• Selected M30A1 as the main propellant</li><li>• Selected small web ball powder as core ignitor</li><li>• Selected round bag black powder as end ignitor</li><li>• Case coating identified to improve waterproofness/compatibility</li><li>• 39 caliber/1150 cu. in. M199 cannon<ul style="list-style-type: none"><li>- 825 m/sec muzzle velocity (MV) demonstrated</li><li>- 24.5 km unassisted/29.8 km assisted</li></ul></li><li>• 52 caliber/1400 cu. in. extended range cannon<ul style="list-style-type: none"><li>- 945 m/sec MV demonstrated</li><li>- 30.4 km unassisted/39.1 km assisted</li></ul></li><li>• Automated storage and retrieval demonstrated - ARM II/Unicharge</li><li>• Additional IM test passed - frag and bullet impact, fast cookoff for a total success of 5 out of 6 (per MIL-STD-2105A)</li></ul>
FY 95
<ul style="list-style-type: none"><li>• Over 3,000 test firings as of 1 August</li><li>• Completed True Unicharge Study for the US Army Field Artillery School</li><li>• Confirmed need to go to stand alone bottom charge</li></ul>



## **Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

### v. ASPA System/MACS Performance

ASPA system with MACS can meet or exceed all Crusader threshold baseline performance requirements with cost, schedule and technical risks fully understood:

Maximum Range	40 km
Minimum Range	6 km
Rate of Fire	10 rds/min for 3-5 mins
RSV Rearm SPH	60 rds/12 mins
Safety Issues	None

### vi. ASPA System Congressional Direction

FY94
<b>Joint Appropriations Conference</b>
<ul style="list-style-type: none"><li>“...complete type classification of XM230 for 39 caliber howitzers not later than third quarter fiscal year 1994 with a follow-on type classification of 52 caliber howitzers on a time schedule consistent with the AFAS program to provide a backup armament suite should the preferred liquid propellant not succeed. ...directs the Army to develop a mount that will allow a “bolt-in/bolt-out” integration of the XM297 cannon with the Paladin Turret.” Added \$18.5M</li></ul>
<b>Joint Authorization Conference</b>
<ul style="list-style-type: none"><li>No language, added \$18.7M in Unicharge line</li></ul>
FY 95
<b>Joint Appropriations Conference</b>
<ul style="list-style-type: none"><li>Continue development of the XM297 cannon</li><li>Continue the XM194 bolt-in/bolt-out mount for the M109 series</li><li>Type classify the XM230 Unicharge for the 39 caliber cannon</li><li>Added \$17.8M in the Unicharge line</li></ul>
<b>Joint Authorization Conference</b>
<ul style="list-style-type: none"><li>Continue engineering development of the XM297 Cannon</li><li>Continue development of the XM194 bolt-in/bolt-out gun mount for potential use in the Paladin</li><li>Type classify the XM230 Unicharge propellant for the standard 39 caliber artillery cannon</li><li>Added \$17.8M in the Unicharge line</li></ul>

**Additional Lessons Learned, Updating, and Notes for Crusader**

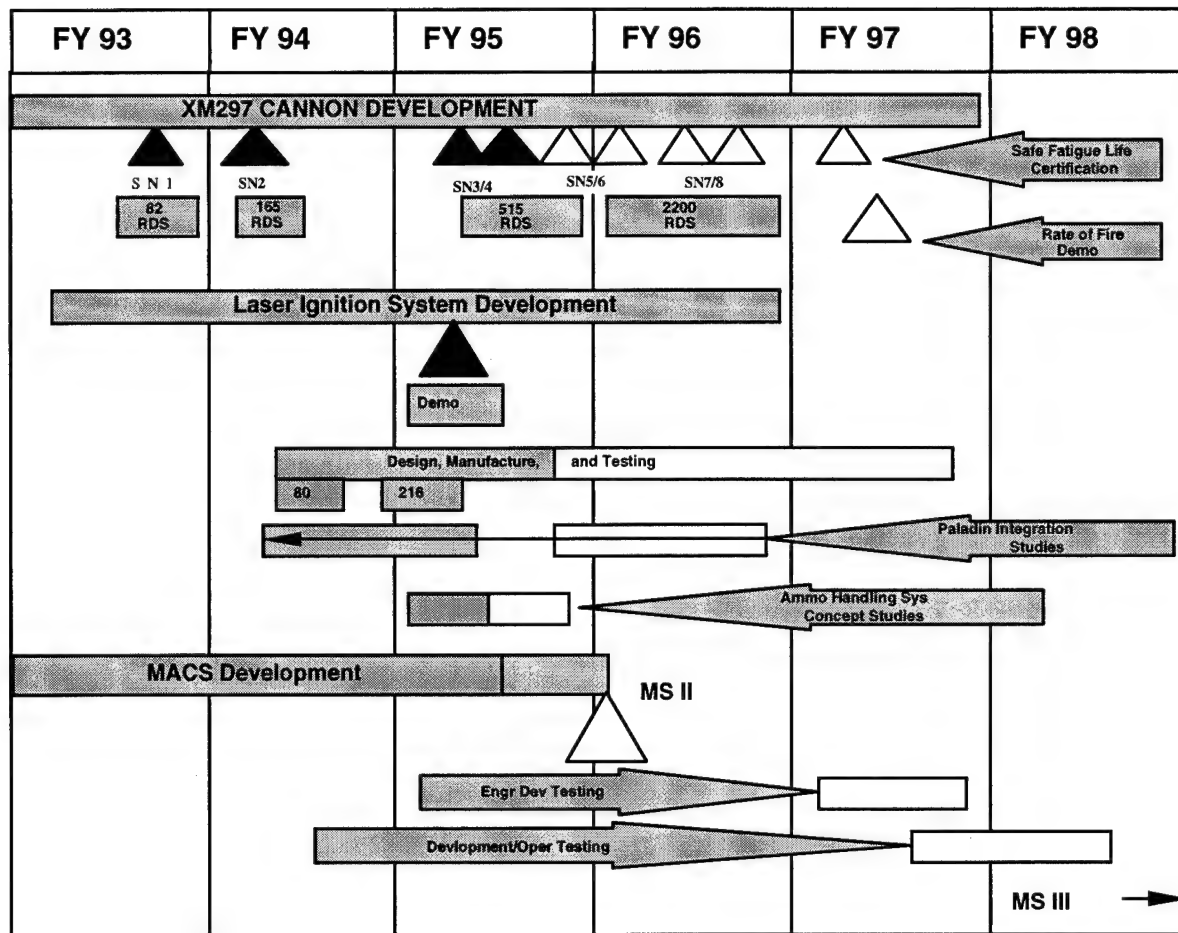
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**NOTES**

# Acquisition, Streamlining and Lessons Learned Report for Crusader

## vii. ASPA System Schedule



## B. Lessons Learned

### LESSONS LEARNED - SOLID PROPELLANT PROGRAM

- Risk reduction can be expensive. Future budgets may force longer technical base programs to eliminate risk before Dem/Val.
- Army budget may not allow full parallel development of solid and liquid propellants. Army must prioritize the main effort to RLPG.
- The Army is unable to develop a true Unicharge system - it must use stand-alone bottom charge. Thus, the type classification of the MACS has slipped to FY98. The impact on Crusader must be assessed.

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**21. AFAS/FARV CONCEPT**

**A. EMD, Contract Definition, Concept Exploration and Development**

*i. Engineer and Manufacturing Development (EMD)*

The EMD, now Phase III, is described in more detail in the "Streamlining" section on page I-19 of this report. Solicitation for the combined AFAS/FARV Development Phases I and II commenced with the release of the RFP on 18 July 1994. See Section 11, page I-63 for the details on the RFP. The contract definition phase will be the vehicle for the prime contractor to prepare and submit a proposal that will define the statement of work and the project plan for Phases I and II of the RFP.

*ii. Contract Definition*

The Contract Definition Phase was required to permit teaming of the Government with the contractor to allow clarification of requirements and provide an expeditious means of transferring concept definition products/data and lessons learned for the preparation of the proposal. The concept of IPD, employed in the AFAS/FARV acquisition and management strategy, initially requires more upfront resources by the contractor to integrate the Government team. It permits a more streamlined approach to contract definition and eliminates the iterative processes of proposal preparation, Government review/comment, contractor proposal revision, and Government re-review and approval. AFAS/FARV IPTs allow the contractor, on the initial submission, to prepare a responsive Statement of Work which describes the contractor's efforts for meeting all of the requirements in Phases I and II of the RFP. Use of this Contract Definition Phase will achieve savings in the execution of the Phase I and II contract by reducing the likelihood of extensive contract modifications. The proposal will become the baseline statement of work from which the contractor and the Government will independently develop cost estimates for the Dem/Val contract.

*iii. Concept Exploration and Development (CED)*

The AFAS and FARV systems completed CED with a Milestone I DAB review, which was approved on 15 November 1994. See page I-69 for the results and guidance of the review. Contract award for a combined AFAS/FARV system Development Phases I and II contract was awarded 31 December 1994.

*iv. Prime Contractor*

The prime contractor is totally responsible for developing the AFAS and FARV systems and is responsible to the Government for delivering operating prototypes of AFAS and FARV vehicles for test and evaluation in accordance with its contract. See page I-34 on how the prime contractor was selected. The prime contractor for the development Phases I and II contract will propose both the AFAS and FARV systems in the response to the RFP. The contractual

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

effort will commence by conducting a systems requirements analysis, refining the AFAS/FARV concepts, and defining common hardware and software and vehicle interfaces.

### v. *Non-Development Items*

The Government solicitation for Dem/Val is based on a performance-oriented system specification, with no mandatory military specifications and very few mandatory military standards. This the prime contractor is to utilize NDIs and commercial components at the subsystem and component level, where practical, to meet defined system performance requirements - a key acquisition/streamlining approach.

### vi. *Commonality*

One of the objectives of Development Phases I and II is to determine the specific elements of common components between the two vehicles. Awarding the AFAS and FARV development to a single contractor, maximizes commonality between the systems, reduces the contractor's engineering and manufacturing effort, and enhances supportability aspects of the AFAS and FARV during subsequent project phases.

### vii. *Development Phase III*

Once AFAS and FARV designs are mature, engineering risks and costs are understood, and Phase II success criteria are met, permission will be requested to enter Development Phase III to complete the development of the two systems and the planning for logistics support and transition to production.

### viii. *Cannon Performance Requirements*

Unlike conventional solid propellant artillery cannons, whose performance is predetermined by the propelling charge, the RLPG tailors its performance by altering its interior ballistics through its ability to reconfigure its components to precisely achieve the desired muzzle velocity. The RLPG is an integral part of the total AFAS system from a number of perspectives: technical and tactical fire control; propellant storage, pumping and management; automatic ammunition handling; power consumption and distribution; mobility platform stabilization; energy dispersion, vehicle configuration and structure; and computational demands. The capability to satisfy all AFAS system performance requirements is dependent upon the prime contractor's ability to influence the design and integration of the RLPG. UDLP has uniquely demonstrated this capability and has acquired the necessary knowledge and skills through previous efforts involving the design and integration of Naval Gun Weapon Systems and integration of the RLPG into the Artillery System Weapons Hardstand for AFAS.

### ix. *Flexibility*

The Crusader System Development contractor must be afforded broad flexibility in making design trades with the constraints of the contract system performance specification. In



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

lieu of the more traditional Government Furnished Equipment approach utilized by the Army for conventional armament systems, it is in the best interest of the Army and the total performance objectives of the AFAS that the RLPG be an integral element of the development contract. This provides the prospective contractor with commensurate design flexibility to consider all parameters that contribute to the total system performance of AFAS.

**B. Lessons Learned**

<b>LESSONS LEARNED - AFAS/FARV CONCEPT</b>
<ul style="list-style-type: none"><li>• In order to preserve the U.S. Artillery industrial base, and avoid front-end costs associated with prototypes and "flyoffs," the Army decided on a single contractor for the AFAS/FARV system.</li><li>• Use of contract definition phase will achieve saving sin Phases I and II.</li><li>• A single contractor maximizes commonality.</li></ul>



**22. UDLP CONCEPT BRIEFING TO THE IGCE TEAM**

**A. Background**

This briefing on the AFAS/FARV concept was presented to the IGCE Team at building 3410 on 17 November 1994. The three briefers were Paul Eskritt, UDLP Project Control Manager; Jerry Nix, UDLP Product Development Team Leader; and Don Underwood, Teledyne Vehicle Systems. The briefing was as follows:

**B. Introduction**

Paul Eskritt presented the introduction. Two baseline concepts were developed during a competitive environment and a downselect is to be performed under the Phase I contract. The objective of the baseline study was to establish a point of departure for further development, to maximize design flexibility, and to establish a configuration that is not sensitive to lower tier trades (e.g., turbine vs. diesel engine, active vs. passive ammunition handling, front vs. rear drive, and liquid propellant vs. Unicharge).

**C. Concept Overview**

Both Jerry Nix and Don Underwood briefed the concept overview. Studies conducted under the baseline concept trades concerned four hull compartments and user priorities. These priorities were lethality, deployability, survivability and sustainability. The physical layout options were explained in detail and included crew, power pack, drive, ammo, trunnion location, gun, and docking. The physical system constraints are given below.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**CONSTRAINTS**

- 55 Ton Combat Loaded Weight
- 113.5 Inch Highway Transport Height
- 132.7 Inch Rail Transport Width
- 312 Inch Vehicle Length (W/O Tube overhang)
- 477 Inch System Length (W/O Tube Overhang)
- 16.9 Inch Ground Clearance

**D. Baseline Design Evolution**

**CONCEPTS**

• Modular	5 Concepts	AFAS/FARV
• Wheeled FARV	2 Concepts	TRACK Vs WHEEL
• LOSAT Based FARV	2 Concepts	NDI Vs NEW START
• Upgraded Paladin/FAASV		
• Super Turret	3 Concepts	CREW in TURRET/HULL
• Super Cab		
• Crew in Hull/Front Engine	2 Concepts	CREW in LOWER HULL
• Crew in Hull/Rear Engine		

**DOWNSELECT TO FOUR**

• Super Turret	WEIGHTED ATTRIBUTES and SCORING CRITERIA
• Super Cab	
• Crew in Hull/Front Engine	
• Crew in Hull/Rear Engine	

**DOWNSELECT TO TWO**

• Crew in Hull/Front Engine
• Crew in Hull/Rear Engine

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**E. Baseline Concept**

SUBSYSTEMS DISCUSSION	
<ul style="list-style-type: none"><li>Hull Structure - 3 inch Space Claim<ul style="list-style-type: none"><li>Aluminum</li><li>Steel</li><li>Titanium</li><li>Composite</li><li>Hybrid</li></ul></li></ul>	
<ul style="list-style-type: none"><li>Suspension<ul style="list-style-type: none"><li>In-Arm Hydroneumatic</li><li>Double-Pin Track; 23 to 25 Inch Wide</li><li>6 or 7 Road Wheels</li></ul></li></ul>	
<ul style="list-style-type: none"><li>Power Train<ul style="list-style-type: none"><li>Engine; Turbine or Diesel</li><li>Transmission; Hydrokinetic, Hydromechanical, or Electric</li></ul></li></ul>	
<ul style="list-style-type: none"><li>Armament<ul style="list-style-type: none"><li>RLPG</li><li>Unicharge</li></ul></li></ul>	
<ul style="list-style-type: none"><li>Ammunition Handling System<ul style="list-style-type: none"><li>Passive (Robotic/Pick-and-Place)</li><li>Active (Rotating Magazines)</li></ul></li></ul>	
<ul style="list-style-type: none"><li>Auxiliary Systems<ul style="list-style-type: none"><li>Gun Drives - Hydraulic, Electro-Hydraulic, or Electro-Servo</li><li>Power Take-Off - Auxiliary Power Unit (APU), Hydraulic, or Electric</li><li>Nuclear Biological and Chemical/Environmental Control System (NBC/ECS)</li></ul></li></ul>	
<ul style="list-style-type: none"><li>Ballistic Survivability<ul style="list-style-type: none"><li>Kinetic Energy (KE) Protection</li><li>Frag Protection</li><li>Top Attack</li></ul></li></ul>	
<ul style="list-style-type: none"><li>Non-Ballistic Survivability<ul style="list-style-type: none"><li>NBC System - Catox and Regenerative Collective Protection System</li><li>Automatic Fire Suppression System</li><li>Compartmentation</li></ul></li></ul>	

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

### WORK SHARE SUMMARY

- United Defense LP  
Prime Contractor and System Integrator  
Armaments Subsystem Integrator  
Electronics Subsystem Integrator  
Survivability Integrator
- Teledyne  
Mobility Subsystem Integrator  
Vehicle Electronics Subsystems
- Martin Marietta  
RLPG Developer  
Resupply Subsystem Integrator
- GDLS  
Vehicle Structure Fabrication  
Communication Systems

### F. Lessons Learned

#### LESSONS LEARNED - UDLP CONCEPT BRIEF TO IGCE

- Briefing slides were distributed at briefing - no time to analyze for questions.
- IGCE IPTs did not receive enough concept detail to effectively proceed.
- A follow-up visit had to be scheduled to UDLP to get effective discussion and learning among the Government/contractor teams.
- In retrospect, certain IPTs had enough definition to begin work in January 1995. Others could not effectively estimate until contractor/Government definition had occurred, as late as June 1995.
- Sequencing IGCE IPT efforts and resources in conformance to concept maturation is a two-edged sword; whenever interface is needed between teams, one team (or more) may not be in force, and, at the system level, costs such as software and test need to be disbursed across the entire system.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## 23. UDLP CRUSADER PROJECT VISION

### A. Background

From the beginning, when the IGCE Team began developing cost estimates, and through 20 February 1995, the IGCE Team was having difficulty trying to cost the Crusader project because of the lack of pertinent data and better definition of what composes Crusader. UDLP had been working on what they called its "Crusader Project Vision," and presented a briefing at Picatinny for the OPM on 22 February 1995. The following were the highlights of the briefing:

PROJECT VISION BRIEFING OUTLINE
<ul style="list-style-type: none"><li>• Objective</li><li>• MS II Exit and Success Criteria</li><li>• Constraints</li><li>• Imperatives</li><li>• Issues</li><li>• Subsystem Development Approach</li><li>• Path Forward</li></ul>



### B. Objective

#### i. A Joint UDLP/OPM Team:

- Shall establish the common, top-level Crusader Project Vision in the form of a single page plan and supporting graphic illustration
- Shall define the system development approach within identified project constraints and imperatives

#### ii. Exit Criteria - MS II

- See page I-69 for the details of the DAE go-ahead.

#### iii. Success Criteria - MS II AFAS

- Range - The contractor shall demonstrate the following range capabilities:
  - Maximum assisted range of at least 40 Km
  - Maximum unassisted range of at least 30 Km
  - Minimum range (@ 200 mils elevation) not to exceed 6 Km

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

- Rate of Fire - The contractor shall demonstrate the following rate of fire capabilities:
  - Maximum rate of fire of at least 10 rds/min for 3 consecutive minutes
  - Sustained rate of fire of at least 3 rds/min for 10 consecutive minutes
  - Sustained rate of fire immediately follows maximum rate of fire
- Multiple Round Simultaneous Impact (MRSI). The contractor shall demonstrate the following MRSI capabilities:
  - Fire a MRSI mission at 10 Km range with a minimum of 4 rds impacting within 6 seconds
  - Fire a MRSI mission at 30 Km range with a minimum of 4 rds impacting within 6 seconds
- Responsiveness. The contractor shall demonstrate the following responsiveness capabilities:
  - Respond to a fire mission request within 20 seconds when emplaced
  - Respond to a fire mission request within 45 seconds when moving
- Accuracy. the contractor shall:
  - Demonstrate predicted fire accuracy at 35 Km range
  - Achieve a bias error not to exceed 253 meters (assuming 1 hr MET)
- Resupply. The contractor shall demonstrate the following resupply capabilities:
  - Automated docking with the FARV, rearm of at least 60 complete rounds
  - Undocking with the FARV in no more than 12 minutes
  - Automated ammunition exchange with the FARV in no more than 20 minutes
- Mobility. The contractor shall demonstrate the following mobility capabilities:
  - Maximum cruising range of at least 405 Km
  - Maximum sustained speed on a level, hard surface road of at least 67 Km/hr
  - Maximum sustained cross-country speed (180 lb/ton rolling resistance) of at least 39Km/hr
  - Survivability move of at least 750 meters in no more than 90 seconds

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

- **Survivability.** The contractor shall demonstrate the following survivability and vulnerability reduction capabilities:
  - Force survivability (AFAS/FARV Battalion) of at least \*% by (analysis)
  - % non-perforation of the vehicle by HE fragmentation of at least \*%
  - % non-perforation of the vehicle by 12.7 mm AP of at least \*%
  - % non-perforation of applicable vehicle areas by DPICM of at least \*%
- \* See Classified Appendix E to the AFAS System Specification
- **Reliability.** The contractor shall demonstrate the following reliability capabilities (point estimates):
  - System mean time between F1 failures of at least 28 hrs
  - System mean time between F2 failures of at least 14 hrs
  - System mean time between F3 failures of at least 7 hrs
- **Maintainability.** At least 60% of the non-depot maintenance tasks shall be capable of being performed by crew or unit mechanics. This requirement may be met by analysis
- **Transportability.** The contractor shall demonstrate the following transportability capabilities. This requirement may be met by analysis:
  - Heavy Equipment Transfer (HET) transportable
  - Rail transportable within NATO envelope B
  - Air (C5/C17) transportable
  - Sea (freighter/LARC-LX) transportable
- **Crew Size.** The contractor shall demonstrate the following crew size capabilities: The AFAS shall be operable by three crewmen over a continuous 96-hour scenario
- **Combat Loaded Weight.** The contractor shall demonstrate the following combat loaded weight capability: Combat loaded weight shall not exceed 50 metric tons (55 tons) at the time of the system's initial fielding

### **C. Success Criteria - MS II FARV**

- **Resupply:**
  - **Upload:** The FARV must be able to be uploaded by the crew with 130 complete rounds in less than 65 minutes from a Combat Configured Load (CCL) on a PLS truck or grounded flatrack. Additionally, the FARV must be able to completely refuel from a tanker within this same time span given that the tanker is in the same location as the CCL.

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

- Payload: The FARV must have the capability to transport 130 complete rounds plus 2 copperheads.
- Rearm of AFAS: Once the vehicles (FARV and AFAS) are with 8 meters of each other, and respective resupply ports are facing each other, the FARV must be able to resupply (dock transfer and undock) AFAS with 60 complete rounds (excluding copperhead) in any operational condition in less than 12 minutes or less.
- Mobility. The contractor shall demonstrate the following mobility capabilities:
  - Maximum cruising range of at least 405 Km
  - Maximum sustained speed on a level, hard surface road of at least 67 Km/hr
  - Maximum sustained cross-country speed (180 lb/ton rolling resistance) of at least 39 Km/hr
  - Survivability move of at least 750 meters in no more than 90 seconds
- Survivability. The contractor shall demonstrate the following survivability and vulnerability reduction capabilities:
  - Force survivability (AFAS/FARV Battalion) of at least \*% by (analysis)
  - % non-perforation of the vehicle by HE fragmentation of at least \*%
  - % non-perforation of the vehicle by 12.7 mm AP of at least \*%
  - % non-perforation of applicable vehicle areas by DPICM of at least \*%

\* See Classified Appendix E to the FARV System Specification
- Reliability. The contractor shall demonstrate the following reliability capabilities (point estimates):
  - System mean time between F1 failures of at least 43 hrs
  - System mean time between F2 failures of at least 24 hrs
  - System mean time between F3 failures of at least 8 hrs
- Maintainability. At least 60% of the non-depot maintenance tasks shall be capable of being performed by crew or unit mechanics. This requirement may be met by analysis
- Transportability. The contractor shall demonstrate the following transportability capabilities. This requirement may be met by analysis:
  - HET transportable
  - Rail transportable within NATO envelope B
  - Air (C5/C17) transportable
  - Sea (freighter/LARC-LX) transportable



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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

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- Crew Size. The contractor shall demonstrate the following crew size capabilities: The FARV shall be operable by three crewmen over a continuous 96-hour scenario.
- Combat Loaded Weight. The contractor shall demonstrate the following combat loaded weight capability: Combat loaded weight shall not exceed 50 metric tons (55 tons) at the time of the system's initial fielding.

### CONSTRAINTS

- Total Program Funding Profile Constant
- Acquisition Program Baseline Goals Must Be Met
- DoD 5000 is Guidance - Waivers Where Appropriate
- MS II date is 04/00
- FUE date is 07/05
- PEO IPR is 06/97 (+3 Months)
- First Prototype Delivery Date Is 10/99
- Success Criteria Must Be Achieved
- PP/DT Decision
- SLICC Oversight
- Exit Criteria Must be Met
- Team Crusader Resources
- Skills/Availability
- Prime/Sub Relationship vis-a-vis IPD
- \$9.9M Contract Definition Funding
- Task 3 Proposal Submission - 1 Sep 95
- System Must Employ the RLPG
- Unicharge Development
- RLPG "Best Effort" Required
- Long Lead Approval for EMD Technologies

### IMPERATIVES

- Resolve Organizational Anxiety
- Define and Improve **System - PDT** Relationships
- Improve **UDLP - Teammate** Relationships
- Define **UDLP - Government** Work Relationships
- UDLP Acting Like Prime - Take Charge
- Flow Down Vision/buy-in to All Organizational Levels
- Achieve **PDT "buy-in" of RACM**
- Formalize Communications within Team Crusader (Action Items, Meetings, Notices, and Minutes)
- Conduct **IPD Training** and Improve Workforce **Productivity**
- Improve Work Facility Support of IPD (Conference Rooms, Team Areas, Etc.)
- Resolve Inefficiencies with **Geographical Locations** of Teammates
- Resolve Inconsistent **PMO "Vision"** (Warren/Picatinny)
- Keep **User** Involved and Informed

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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### IMPERATIVES

- Identify, Exploit and Leverage Acquisition Reform Opportunities
- Define Phase I/II Expectations (What is required to ensure the proposal is accepted upon submittal -- Real Time technical evaluations?)
- Define UDLP role in all Government Work Packages
- Determine Disposition of CED Assets
- Define Scope of Battle Lab Interaction (How can it best benefit the program?)
- Define Man-rated Prototype Requirements/Expectations (i.e., which tasks will be man-rated, driving, firing,...)
- Conduct Early RLPG Component Maturation IPR (Prior to PEO IPR)
- Streamline testing (multipurpose) - conduct Joint Contractor/Government Testing
- Establish Focused, Well-defined Risk Management Approach
- Define and Implement Competition Plan
- Minimize G&A/Fee Stacking
- Define Section L
- UDLP's Control of the End-to-end RLPG Model
- Get Plan for Dem/Val Program Done

### ISSUES

- Team Crusader Organization - Unsettled
- UDLP Management of Government Work Packages to Support Development Effort
- UDLP Control of Other Government Agencies (Those Integral to Development)
- UDLP Control of Subcontractors
- DLP Pricing Methodology/cost Plan
- Reduction of Contractor G&A/Fee Stacking
- Stand-alone Cannon Systems Requirements Analysis (SRA) at MMDS
- Government Real-time Technical Evaluation of Task 3 Proposal
- Tough RLPG Decision (Less than Complete Success)
- Better Understanding of Circular Error Probables (CEPs) and Force Development Test and Experimentation (FDT&E) Purpose, Scope and Timing
- Early Authorization to Acquire Long Lead Items (LLIs) for EMD Granted
- CITIS Importance and Factoring it into Overall Solutions to Problems
- Consensus Definition of a **Limited Prototype**

### SYSTEM DEVELOPMENT APPROACH

- Top Level "Vision" for Phase I/II
- Initial Top Level "Vision"
- Production Vision
- Training and Support Vision
- Key Products of Plan for Phase I/II
- System Development Approach - How is it Different?
- Modeling and simulation
- Virtual Prototypes
- System Level Integration Demonstrator
- Iterative System Development - Rapid Prototyping, Modeling, and Simulation
- Electronics and Software Development and Integration Laboratory

**Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

### SYSTEM DEVELOPMENT APPROACH

- Full Function Crew Modules - SPH and RSV
- Integration, Assembly, Test and Checkout (IAT&C) "Iron" Test Rig
- Prototype Evolution from ATR
- Automotive Test Rigs (ATR)
- End Cycle Pre-Prototypes
- Phase III Prototypes
- RLPG Hardstands
- Surrogate Vehicle Candidates for CEP and FDT&E
- Crew Modules - Mobile
- Iterative Evolution of System and C3 and Crew Concepts
- Training and support Products
- CITIS Implementation Time Table

### D. Path Forward

#### NEAR TERM

- Complete first Iteration of Top-Level Development by 5 March 1995
- Schedule Sessions with PDT Leaders to Collect Inputs on Constraints, imperatives and Top Level Program Approach
- Complete and Resolve Issues List (Where Possible)
- Plan, Action and Resolve Imperatives
- Refine approach/Plan and Present Results to PM 5 March 1995
- Use Results as Point of Departure for System and Element Level Planning

#### LONG TERM

- Execute the Phase I/II Proposal Preparation Schedule

### E. Lessons Learned

#### LESSONS LEARNED - UDLP CRUSADER PROJECT VISION

- The vision gave the IGCE insight to the Crusader costing effort and a good plan to proceed with.
- The vision provided good definition of what composes Crusader.
- It provided the IGCE pertinent data for better costing and an integrated approach.
- It gave the IGCE a better understanding of major issues with Crusader.

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## 24. WORK BREAKDOWN STRUCTURE (WBS) FACT SHEETS

### A. Background

On 9 December 1994, the seven functional area teams were tasked to prepare fact sheets on the AFAS/FARV WBS elements within their areas. The format followed by all the teams was the outline of the Cost Analysis Requirements Document (CARD).

### B. Outline

The CARD outline was tailored by Mort Anvari and recorded on an MS Word document using the outline feature. This feature creates an outline with indented and numbered headings. The team members would receive the outline on disk, modify the header to indicate their WBS element and fill in their specific text under the common headings. The WBS is shown below:

<b>WBS Element:</b> 00000	<b>WBS Title:</b> Crusader Program
The Crusader program element refers to the total complement of equipment, software, data, services, facilities, training, management, integration and support representing the complete Crusader system. Efforts include all services and functions of system engineering and program management.	
<b>WBS Element:</b> 10000	<b>WBS Title:</b> Self Propelled Howitzer (SPH)/Resupply Vehicle (RSV)
<p>The SPH portion of this element refers to the primary means for delivering the destructive effect to the target employing all 155-mm self-propelled howitzer systems and associated subsystems, including the capability to generate and receive intelligence, and navigate successfully to achieve mission requirements. It also includes the design, development, and assembly of complete prototype units which satisfy the requirements delineated in the Crusader system specification under all specified environments and design constraints.</p> <p>The RSV portion of this element refers to the self-propelled armored resupply vehicle system which embodies the means to acquire ammunition and other resupply assets at a resupply point and execute resupply operations to provide the SPH assets necessary to accomplish its mission. It also includes the design, development, integration and assembly of the complete prototype units which satisfy the requirements delineated in the Crusader system specification under all specified environments and design constraints.</p>	



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## Acquisition, Streamlining and Lessons Learned Report for Crusader

<b>WBS Element:</b> 11000	<b>WBS Title:</b> SPH Integration, Assembly Test and Checkout
<p>The SPH Integration, Assembly Test and Checkout element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble the level 3 equipment (hardware/software) elements into a level 2 mission equipment (hardware/software) as a whole and not directly part of any other individual level 3 element. It refers to all efforts associated with the concept definition, preliminary design, detail design and system integration of SPH phase II prototype vehicles. This includes ensuring that the segment meets all segment level performance requirements. Included in this element are design analyses, computer simulations, physical/math models, schematics, flow diagrams, mockups, design validation/verification, integrated power, volume and weight budget analyses, integration analyses, vulnerability and susceptibility reduction measures, lower tier specifications, interface documents and other engineering documents and all other methods employed to develop an integrated set of requirements, design criteria, concepts and technical data describing the complete segment.</p> <p>The Test and Checkout element refers to all system test and checkout efforts up to the point of completion of fabrication of the Crusader phase II prototype vehicles. Included are tests of assemblies from the combination of two or more level 3 WBS elements. This effort also includes development of system level integration test plans, procedures and test reports in accordance with the program Master Test Plan and the planning, conduct and reporting of integration-related vehicle tests. Activities relating to verification of system level requirements and the development and maintenance of the program Master Test Plan are included in WBS element 20000. The test plans and procedures activities in this WBS element apply to development of the system integration and vehicle tests that will be conducted during SPH integration. The test reports activities in this WBS element provide reports of tests conducted during SPH integration.</p> <p>The vehicle test activities in this WBS element are those tests that verify vehicle performance to SPH segment specification but that are not necessarily associated with integration of subsystems.</p>	
<b>WBS Element:</b> 11100	<b>WBS Title:</b> System Level Integration Demonstrator (SLID)
<p>This element refers to the design engineering, fabrication, evaluation, integration and demonstration of SPH combat system capabilities via simulators, stimulators, emulators, mock-ups and prototype system hardware and software components to perform experiments, measure system effectiveness and assess battlefield virtual reality in a Distributed Interactive Simulation (DIS) environment. This element will incorporate the products of WBS elements 11900 (Simulators and Stimulators) and 11B00 (Modeling and Simulation) as well as hardware, software, virtual prototypes, simulation and models produced by other Crusader Vehicle System level 3 WBS elements.</p>	

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

<b>WBS Element:</b> 11200	<b>WBS Title:</b> Auxiliary Systems Architecture
<p>The auxiliary systems architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for auxiliary systems components. This element refers to the integration, assembly, test and check out of that group of SPH subsystems (hardware and software) which provide services to the SPH. This element includes, for example, the integration of the vehicle electrical or electronics subsystems, onboard diagnostics/prognostics subsystems, vehicle hydraulics, fire extinguishers and accessories such as lighting. Also included is support of system level analyses and interface definitions required to incorporate "crew station" manprint/human factors/environmental concepts. This element also includes analysis, specification, interface definition and integration of SPH decision aid equipments and their associated data display and control equipments. Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of segment requirements. The integrated auxiliary systems shall be tested to prescribed performance criteria.</p>	
<b>WBS Element:</b> 11300	<b>WBS Title:</b> System Thermal Management
<p>The system thermal management architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for system thermal management components</p> <p>This element refers to the integration assembly, test and check out of those equipments and systems designed for the removal of heat generated by onboard machinery, equipment and systems so that vehicle components operate below maximum specified operating temperature in all operating environments. These equipments generally include ducting, pumps, plumbing, plenums, reservoirs, filtration devices, heat exchangers, controls, sensors, displays, etc. needed to provide conditioned air, fluids/gases or other thermal services. These components will interface as needed to provide integrated control of the vehicle thermal management system including thermal signature management components. Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of segment requirements.</p>	

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

<b>WBS Element:</b>	<b>11400</b>	<b>WBS Title:</b>	<b>Survivability Architecture</b>
<p>The survivability architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for survivability components. This element refers to those efforts associated with the SPH avoiding or withstanding the effects of hostile environments and/or threat actions under all specified environments and design constraints in order to sustain combat performance at specified levels. Included in this element are all development and integration activities needed to meet susceptibility and vulnerability reduction requirements as specified. Among these requirements are ballistic protection (penetration avoidance against direct and indirect fire and mines); non-ballistic protection (detection avoidance against threat surveillance and target acquisition); acquisition/hit avoidance against hit-to-kill and shoot-to-kill smart munitions; and kill/damage/mission degradation avoidance against overmatching threats; fires, explosive forces, fratricide, radiation, and directed energy and electro-magnetic environmental effects). Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of segment requirements. This effort includes the integration, assembly, test and checkout of sub-tier components developed at the element level.</p>			
<b>WBS Element:</b>	<b>11500</b>	<b>WBS Title:</b>	<b>Electronics Architecture</b>
<p>The electronic architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS elements into a physical configuration for electronics components. This element refers to the integration of all WBS level 3 SPH subsystem hardware and software data processing unit(s) responsible for coordinating, directing, and executing the Crusader subsystems mission. This element contains embedded software, that is, software defined in the Crusader specification and provided by the electronics integrator. This element refers to all effort required to design, develop, integrate and checkout (including support to independent verification and validation (IV&amp;V) the Crusader electronics software build and CSCI. This effort includes the integration, assembly, test and checkout of sub-tier components developed at the element level. It also includes the integration of embedded training and maintenance capabilities and the specification of electronics architecture "hooks" and connections for interface with "off board" trainers and maintenance equipments.</p>			
<b>WBS Element:</b>	<b>11600</b>	<b>WBS Title:</b>	<b>Vehicle Structure Definition</b>
<p>The vehicle structure definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for SPH vehicle components. This element refers to the integration, assembly, test and check out of a complete SPH vehicle structure. It includes all hardware items associated with providing crew and on-vehicle equipment encapsulation and structure. Included are structure, surface plates, frames, braces and other reinforcements for the crew, engine, ammunition and weapon compartments as well as any appendages which attach directly to the primary structure. Appendages include items affixed to the vehicle structure for the purpose of lifting and towing the SPH during production, transport, towing, and vehicle recovery; items affixed to the structure needed to tow trailers, similar vehicles, interface with vehicle retrievers (i.e. lifting eyes and towing pintles); and all hatches doors, grilles, cupolas, fenders, skirts, plates covers, guards, stowage racks and boxes, and other appendages. Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of SPH requirements. This effort will include the integration, assembly, test and check out of sub-tier components produced by other level 3 WBS elements.</p>			

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

<b>WBS Element:</b> 11700	<b>WBS Title:</b> Integration Planning
This element refers to the effort to develop a comprehensive plan to systematically integrate, assemble and test the demonstrator SPH vehicle combat system. The plan includes facilities, instrumentation, and simulators/stimulators/emulators required to integrate the vehicle, the sequence of subsystem integration, and the progressive testing that will be performed to complete checkout of the entire vehicle combat system. Integration planning activities below the segment level will be carried out in the product development function of each PDT	
<b>WBS Element:</b> 11800	<b>WBS Title:</b> Integration Parts, Equipment & Materials
This element refers to the effort to define, develop and maintain a master list of Integration Parts, Equipment & Materials required to integrate the SPH vehicle, such as special tools, facilities and test equipments specific to vehicle integration. It also includes the specification, design, procurement and/or fabrication of these in accordance with activities described in the IMP and the SPH Integration Plan. The element does not include major System Integration Laboratory equipment acquisition as contained in WBS element 31612.	
<b>WBS Element:</b> 11900	<b>WBS Title:</b> Simulators and Stimulators
The simulators and stimulators activities in this WBS element consist of analysis, design, fabrication and test of equipment to support electronic and software integration at the SPH segment level. The simulators and stimulators will be used to checkout, verify and test combinations of subsystems and integrated functional elements up to the SPH segment level. This WBS element does not include simulators and stimulators used to test individual assembled subsystems. Similar activities may be carried out at the element and subsystem level and are supported in the product development function of each PDT.	
<b>WBS Element:</b> 11A00	<b>WBS Title:</b> Software Integration
The software integration activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical/logical configuration for software components. This element refers to the effort to analyze, design, and develop the interfaces, special test software and data reduction and collection equipment to integrate all the SPH CSCIs and to ensure that the integrated software systems function as specified.	
<b>WBS Element:</b> 11B00	<b>WBS Title:</b> Modeling and Simulation
This element refers to those efforts to integrate, assemble, test and checkout those computer simulations, physical/math models, and mockups required to assess SPH interface definitions, conduct performance measurement/predictions/demonstrations and perform design analyses/validations for the SPH vehicle combat systems. This effort will include the integration, assembly, test and check out of models and simulations produced other level 3 WBS elements for incorporation into SPH segment level models/simulations within the SIL/SLID, as well as those simulators/stimulators developed in conjunction with WBS element 11900 (Simulators and Stimulators). This effort will support Crusader System modeling and simulation activities as defined in WBS element 31700.	
<b>WBS Element:</b> 11C00	<b>WBS Title:</b> SPH Integration
The SPH Integration element refers to all efforts associated with the concept definition, preliminary design, detail design and system integration of the SPH phase II prototype vehicles. This includes ensuring that the system meets all system level performance requirements. Included in this element are design analyses, computer simulations, physical/math models, schematics, flow diagrams, mockups, design validation/verification, integrated power, volume and weight budget analyses, integration analyses, lower tier specifications, interface documents and other engineering documents and all other methods employed to develop an integrated set of requirements, design criteria, concepts and technical data describing the complete system.	



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<b>WBS Element:</b> 11D00	<b>WBS Title:</b> Test Plans, Procedures & Reports
<p>The test planning and procedures activities in this WBS element consist of development of a comprehensive plan for SPH combat system and vehicle tests that will be conducted during SPH integration.. The plan will be in contractor format and should include facilities, instrumentation, simulators, stimulators and emulators required for SPH testing. The plan should also address the sequence of subsystem progressive testing that will be performed to complete the testing effort, and the test reports required for documentation of test results.. Test planning activities below the subsystem level will be carried out in the product development function of each PDT.</p>	
<b>WBS Element:</b> 11E00	<b>WBS Title:</b> SPH Vehicle Tests
<p>This element refers to all prototype and/or specially fabricated hardware and software used to generate, verify or validate engineering data on the performance of the SPH demonstrator/prototype. It includes the specification, procurement or design, fabrication and test of all parts, materials, equipments, and special hardware and software required to inspect, checkout and test the SPH demonstrator vehicle. Included are tests of assemblies from the combination of two or more Level 3 Combat System WBS elements, as well as testing of complete SPH system demonstrators/prototypes when conducted as other than complete Crusader System tests (WBS 20000).</p>	
<b>WBS Element:</b> 12000	<b>WBS Title:</b> RSV Integration, Assembly Test and Checkout
<p>The RSV Integration, Assembly Test and Checkout element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble the level 3 equipment (hardware/software) elements into a level 2 mission equipment (hardware/software) as a whole and not directly part of any other individual level 3 element. It refers to all efforts associated with the concept definition, preliminary design, detail design and system integration of RSV phase II prototype vehicles. This includes ensuring that the segment meets all segment level performance requirements. Included in this element are design analyses, computer simulations, physical/math models, schematics, flow diagrams, mockups, design validation/verification, vulnerability and susceptibility reduction measures, integrated power, volume and weight budget analyses, integration analyses, lower tier specifications, interface documents and other engineering documents and all other methods employed to develop an integrated set of requirements, design criteria, concepts and technical data describing the complete segment.</p> <p>The Test and Checkout element refers to all system test and checkout efforts up to the point of completion of fabrication of the Crusader phase II prototype vehicles. Included are tests of assemblies from the combination of two or more level 3 WBS elements This effort also includes development of system level integration test plans, procedures and test reports in accordance with the program Master Test Plan and the planning, conduct and reporting of integration-related vehicle tests. Activities relating to verification of system level requirements and the development and maintenance of the program Master Test Plan are included in WBS element 20000.</p> <p>The test plans and procedures activities in this WBS element apply to development of the system integration and vehicle tests that will be conducted during RSV integration.</p> <p>The test reports activities in this WBS element provide reports of tests conducted during RSV integration.</p> <p>The vehicle test activities in this WBS element are those tests that verify vehicle performance to RSV segment specification but that are not necessarily associated with integration of subsystems.</p>	

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<b>WBS Element:</b> 12100	<b>WBS Title:</b> System Level Integration Demonstrator (SLID)
<p>This element refers to the design engineering, fabrication, evaluation, integration and demonstration of RSV combat system capabilities via simulators, stimulators, emulators, mock-ups and prototype system hardware and software components to perform experiments, measure system effectiveness and assess battlefield virtual reality in a Distributed Interactive Simulation (DIS) environment. This element will incorporate the products of WBS elements 12900 (Simulators and Stimulators) and 12B00 (Modeling and Simulation) as well as hardware, software, virtual prototypes, simulation and models produced by other Crusader Vehicle System level 3 WBS elements.</p>	
<b>WBS Element:</b> 12200	<b>WBS Title:</b> Auxiliary Systems Architecture
<p>The auxiliary systems architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for auxiliary systems components. This element refers to the integration, assembly, test and check out of that group of RSV subsystems (hardware and software) which provide services to the RSV. This element includes, for example, the integration of the vehicle electrical or electronics subsystems, onboard diagnostics/prognostics subsystems, vehicle hydraulics, fire extinguishers and accessories such as lighting. Also included is support of system level analyses and interface definitions required to incorporate "crew station" manprint/human factors/environmental concepts. This element also includes analysis, specification, interface definition and integration of SPH decision aid equipments and their associated data display and control equipments. Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of segment requirements. The integrated auxiliary systems shall be tested to prescribed performance criteria.</p>	
<b>WBS Element:</b> 12300	<b>WBS Title:</b> System Thermal Management
<p>The system thermal management architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for system thermal management components</p> <p>This element refers to the integration assembly, test and check out of those equipments and systems designed for the removal of heat generated by onboard machinery, equipment and systems so that vehicle components operate below maximum specified operating temperature in all operating environments. These equipments generally include ducting, pumps, plumbing, plenums, reservoirs, filtration devices, heat exchangers, controls, sensors, displays, etc. needed to provide conditioned air, fluids/gases or other thermal services. These components will interface as needed to provide integrated control of the vehicle thermal management system including thermal signature management components. Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of segment requirements.</p>	

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<b>WBS Element:</b> 12400	<b>WBS Title:</b> Survivability Architecture
<p>The survivability architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for survivability components. This element refers to those efforts associated with the RSV avoiding or withstanding the effects of hostile environments and/or threat actions under all specified environments and design constraints in order to sustain combat performance at specified levels. Included in this element are all development and integration activities needed to meet susceptibility and vulnerability reduction requirements as specified. Among these requirements are ballistic protection (penetration avoidance against direct and indirect fire and mines); non-ballistic protection (detection avoidance against threat surveillance and target acquisition); acquisition/hit avoidance against hit-to-kill and shoot-to-kill smart munitions; and kill/damage/mission degradation avoidance against overmatching threats; fires, explosive forces, fratricide, radiation, and directed energy and electro-magnetic environmental effects). Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of segment requirements. This effort includes the integration, assembly, test and checkout of sub-tier components developed at the element level.</p>	
<b>WBS Element:</b> 12500	<b>WBS Title:</b> Electronics Architecture
<p>The electronic architecture definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS elements into a physical configuration for electronics components. This element refers to the integration of all WBS level 3 RSV subsystem hardware and software data processing unit(s) responsible for coordinating, directing, and executing the Crusader subsystems mission. This element contains embedded software, that is, software defined in the Crusader specification and provided by the electronics integrator. This element refers to all effort required to design, develop, integrate and checkout (including support to independent verification and validation (IV&amp;V) the Crusader electronics software build and CSCI. This effort includes the integration, assembly, test and checkout of sub-tier components developed at the element level. It also includes the integration of embedded training and maintenance capabilities and the specification of electronics architecture "hooks" and connections for interface with "off board" trainers and maintenance equipments.</p>	

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<b>WBS Element:</b> 12600	<b>WBS Title:</b> Vehicle Structure Definition
<p>The vehicle structure definition activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical configuration for RSV vehicle components. This element refers to the integration, assembly, test and check out of a complete RSV vehicle structure. It includes all hardware items associated with providing crew and on-vehicle equipment encapsulation and structure. Included are structure, surface plates, frames, braces and other reinforcements for the crew, engine, ammunition and weapon compartments as well as any appendages which attach directly to the primary structure. Appendages include items affixed to the vehicle structure for the purpose of lifting and towing the RSV during production, transport, towing, and vehicle recovery; items affixed to the structure needed to tow trailers, similar vehicles, interface with vehicle retrievers (i.e. lifting eyes and towing pintles); and all hatches doors, grilles, cupolas, fenders, skirts, plates covers, guards, stowage racks and boxes, and other appendages. Included in this element are design analyses, lower tier specifications, interface documents, volume/weight budgets and other engineering criteria, concepts and technical data required for an integrated set of RSV requirements. This effort will include the integration, assembly, test and check out of sub-tier components produced by other level 3 WBS elements.</p>	
<b>WBS Element:</b> 12700	<b>WBS Title:</b> Integration Planning
<p>This element refers to the effort to develop a comprehensive plan to systematically integrate, assemble and test the demonstrator RSV vehicle combat system. The plan includes facilities, instrumentation, and simulators/stimulators/emulators required to integrate the vehicle, the sequence of subsystem integration, and the progressive testing that will be performed to complete checkout of the entire vehicle combat system. Integration planning activities below the segment level will be carried out in the product development function of each PDT</p>	
<b>WBS Element:</b> 12800	<b>WBS Title:</b> Integration Parts, Equipment & Materials
<p>This element refers to the effort to define, develop and maintain a master list of Integration Parts, Equipment &amp; Materials required to integrate the RSV vehicle, such as special tools, facilities and test equipments specific to vehicle integration. It also includes the specification, design, procurement and/or fabrication of these in accordance with activities described in the IMP and the RSV Integration Plan. The element does not include major System Integration Laboratory equipment acquisition as contained in WBS element 31612.</p>	
<b>WBS Element:</b> 12900	<b>WBS Title:</b> Simulators and Stimulators
<p>The simulators and stimulators activities in this WBS element consist of analysis, design, fabrication and test of equipment to support electronic and software integration at the RSV segment level. The simulators and stimulators will be used to checkout, verify and test combinations of subsystems and integrated functional elements up to the RSV segment level. This WBS element does not include stimulators and simulators used to test individual assembled subsystems. Similar activities may be carried out at the element and subsystem level and are supported in the product development function of each PDT.</p>	
<b>WBS Element:</b> 12A00	<b>WBS Title:</b> Software Integration
<p>The software integration activities in this WBS element consist of analysis, modeling, specification and trade studies to translate the system functional concept and baseline functional configuration developed under the system engineering function WBS element into a physical/logical configuration for software components. This element refers to the effort to analyze, design, and develop the interfaces, special test software and data reduction and collection equipment to integrate all the RSV CSCIs and to ensure that the integrated software systems function as specified.</p>	



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<b>WBS Element:</b> 12B00	<b>WBS Title:</b> Modeling and Simulation
<p>This element refers to those efforts to integrate, assemble, test and checkout those computer simulations, physical/math models, and mockups required to assess RSV interface definitions, conduct performance measurement/predictions/demonstrations and perform design analyses/validations for the RSV vehicle combat systems. This effort will include the integration, assembly, test and check out of models and simulations produced by other level 3 WBS elements for incorporation into RSV segment level models/simulations within the SIL/SLID, as well as those simulators/stimulators developed in conjunction with WBS element 12900 (Simulators and Stimulators). This effort will support Crusader System modeling and simulation activities as defined in WBS element 31700.</p>	
<b>WBS Element:</b> 12C00	<b>WBS Title:</b> RSV Integration
<p>The RSV Integration element refers to all efforts associated with the concept definition, preliminary design, detail design and system integration of the RSV phase II prototype vehicles. This includes ensuring that the system meets all system level performance requirements. Included in this element are design analyses, computer simulations, physical/math models, schematics, flow diagrams, mockups, design validation/verification, integrated power, volume and weight budget analyses, integration analyses, lower tier specifications, interface documents and other engineering documents and all other methods employed to develop an integrated set of requirements, design criteria, concepts and technical data describing the complete system.</p>	
<b>WBS Element:</b> 12D00	<b>WBS Title:</b> Test Plans, Procedures & Reports
<p>The test planning and procedures activities in this WBS element consist of development of a comprehensive plan for RSV combat system and vehicle tests that will be conducted during RSV integration.. The plan will be in contractor format and should include facilities, instrumentation, simulators, stimulators and emulators required for RSV testing. The plan should also address the sequence of subsystem progressive testing that will be performed to complete the testing effort, and the test reports required for documentation of test results.. Test planning activities below the subsystem level will be carried out in the product development function of each PDT.</p>	
<b>WBS Element:</b> 12E00	<b>WBS Title:</b> RSV Vehicle Tests
<p>This element refers to all prototype and/or specially fabricated hardware and software used to generate, verify or validate engineering data on the performance of the RSV demonstrator/prototype. It includes the specification, procurement or design, fabrication and test of all parts, materials, equipments, and special hardware and software required to inspect, checkout and test the RSV demonstrator vehicle. Included are tests of assemblies from the combination of two or more Level 3 Combat System WBS elements, as well as testing of complete RSV system demonstrators/prototypes when conducted as other than complete Crusader System tests (WBS 20000).</p>	
<b>WBS Element:</b> 13000	<b>WBS Title:</b> Armament
<p>The Armament element refers to a means to deliver indirect and direct fire. Fire control is not included as a part of this element. Armament risk mitigation and component maturation activities are included in the product development function of this element. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the armament hardstands and intermediate and final armament test equipment. All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the SPH is excluded.</p>	

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<b>WBS Element:</b> 13100	<b>WBS Title:</b> RLPG Subsystem
The RLPG subsystem refers to hardware associated with operation, initiation and combustion control of the Regenerative Liquid Propellant Gun (RLPG). It is comprised of the breech mechanism, breech block assembly, combustor assembly, igniter assembly, and tube assembly. The igniter furnishes hot gas to pressurize and initiate the regenerative combustion process in the chamber. The breech block assembly provides a metered quantity of LP into the chamber during the regenerative combustion process. This effort includes all activities associated with the design, development, integration, fabrication, assembly, and test of the RLPG Subsystem.	
<b>WBS Element:</b> 13110	<b>WBS Title:</b> Breech Mechanism Assembly
The breech mechanism refers to the mechanical hardware and actuator(s) required to achieve controlled opening and closing of the breech block assembly. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the breech mechanism.	
<b>WBS Element:</b> 13120	<b>WBS Title:</b> Breech Block Assembly
The breech block assembly refers to the hardware associated with breech sealing and combustion control. It is comprised of the breech seal which provides obturation at the breech combustor interface and injector hardware which provide a reservoir region in the gun and the hydraulic controls for to deliver a metered quantity of LP injection into the chamber during combustion. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the breech block assembly.	
<b>WBS Element:</b> 13130	<b>WBS Title:</b> Combustor Assembly
The combustor refers to the pressure vessel in which combustion occurs. The combustor assembly interfaces with the breech block assembly and tube assemblies and includes any associated sensors, seals and valves. This includes the seal at the combustor-tube interface. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the combustor.	
<b>WBS Element:</b> 13140	<b>WBS Title:</b> Igniter Assembly
The igniter refers to the mechanism which provides the proper volume of hot gas at the required rate to initiate the regenerative injection process. The igniter is electrically triggered. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the igniter. This effort includes mock chamber testing and the evaluation of alternative ignition methods.	
<b>WBS Element:</b> 13150	<b>WBS Title:</b> Tube Assembly
The tube assembly refers to the gun tube, the bore evacuator, the muzzle brake and the hardware necessary for thermal management. The tube assembly provides the interface for combustor-tube sealing. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the tube assembly.	
<b>WBS Element:</b> 13160	<b>WBS Title:</b> RLPG Subsystem I,A,T&C
This element includes all efforts associated with the integration, assembly, test and check out of the RLPG.	
<b>WBS Element:</b> 13200	<b>WBS Title:</b> Gun Mount Subsystem
The Gun Mount Subsystem refers to all hardware designed to provide an interface between the RLPG and the platform used to transport and aim it. During firing, the gun mount absorbs the recoil force of the cannon assembly and returns the cannon to its in-battery position. This effort includes all efforts associated with the design, development, integration, fabrication, assembly, and test of the Gun Mount Subsystem.	

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<b>WBS Element:</b> 13210	<b>WBS Title:</b> Gun Cradle Assembly
The gun cradle assembly refers to the housing for the recoil and counter-recoil assemblies. The cradle assembly includes the bearing on which the barrel is both statically and dynamically supported and the trunnion bearing on which the tube and cradle assembly pivot. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the gun cradle.	
<b>WBS Element:</b> 13220	<b>WBS Title:</b> Recoil Assembly
The recoil assembly is mechanically coupled to the RLPG assembly and provides controlled damping of the energy associated with the recoil of the RLPG during firing. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the recoil assembly.	
<b>WBS Element:</b> 13230	<b>WBS Title:</b> Counterrecoil Assembly
The counterrecoil assembly provides the controlled return of the RLPG to the in-battery position following a firing and subsequent recoil cycle. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the counterrecoil assembly.	
<b>WBS Element:</b> 13240	<b>WBS Title:</b> Gun Mount Subsystem I,A,T&C
This element includes all efforts associated with the integration, assembly, test and check out of the RLPG Mount.	
<b>WBS Element:</b> 13300	<b>WBS Title:</b> Projectile Loader Subsystem
The Projectile Loader Subsystem element refers to all hardware required to transfer a fuze projectile from SPH storage to position for firing and download. The projectile loader subsystem interfaces to the projectile storage and transfer equipment. This effort includes all activities associated with the design, development, integration, fabrication, assembly and test of the projectile loader subsystem.	
<b>WBS Element:</b> 13310	<b>WBS Title:</b> Loader Assembly
The loader assembly refers to the electro-mechanical actuator(s) which accept(s) the projectile from the storage magazine(s) and transfers it to the rammer in preparation for firing the gun. Included are all efforts associated with the design, development, integration, fabrication, assembly, and test of the loader assembly.	
<b>WBS Element:</b> 13320	<b>WBS Title:</b> Rammer Assembly
The rammer refers to the electro-mechanical actuator which receives the projectile from the loader assembly and rams the projectile through the open breech into the tube of the gun in preparation for firing. Included are all efforts associated with the design, development, integration, fabrication, assembly, and test of the rammer.	
<b>WBS Element:</b> 13330	<b>WBS Title:</b> Projectile Loader Subsystem I,A,T&C
This element includes all efforts associated with the integration, assembly, test and check out of the Projectile Loader Subsystem.	
<b>WBS Element:</b> 13400	<b>WBS Title:</b> Fluid Handling Subsystem
The Fluid Handling Subsystem refers to all hardware required to transfer propellant and POL from SPH storage to position for firing. Included are all efforts associated with the transfer and download of the essential and expendable fluids required for safe operation of the RLPG System. The fluid handling subsystem includes the propellant fill assembly, the lubrication delivery assembly, the damper supply and cooling assembly and the dousing and safing assembly.	
<b>WBS Element:</b> 13410	<b>WBS Title:</b> Propellant Fill Assembly
The propellant fill assembly refers to all hardware required to meter to the RLPG assembly the correct amounts of LP within the prescribed time. This effort includes the design, development, integration, fabrication, assembly and test of the propellant fill assembly.	

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<b>WBS Element:</b> 13420	<b>WBS Title:</b> Lubrication Assembly
The lubrication assembly refers to all hardware associated with providing sufficient lubrication to the hydrodynamic seals and the sliding surfaces of the inner and outer pistons. This effort includes all activities associated with the design, development, integration, assembly and test of the lubrication assembly.	
<b>WBS Element:</b> 13430	<b>WBS Title:</b> Damper Supply and Cooling Assembly
The damper supply and cooling assembly refers to the hardware required to maintain a supply of cool hydraulic fluid within the damper. It includes the damper fluid storage tanks, pumps and associated hydraulic equipment. This effort includes all activities associated with the design, development, integration, assembly and test of the damper supply and cooling assembly.	
<b>WBS Element:</b> 13440	<b>WBS Title:</b> Dousing and Safing Assembly
The dousing and safing assembly refers to the hardware required to dilute and purge the LP from the igniter in the event of a check fire. This effort includes all activities associated with the design, development, integration, assembly and test of the dousing and safing assembly.	
<b>WBS Element:</b> 13450	<b>WBS Title:</b> Fluid Handling Subsystem I,A,T&C
This element includes all efforts associated with the integration, assembly, test and check out of the Fluid Handling Subsystem.	
<b>WBS Element:</b> 13500	<b>WBS Title:</b> Gun Pointing Subsystem
The Gun Pointing Subsystem refers to the hardware necessary to elevate (including equilibration) and traverse the gun, to hold the gun in position during firing and to secure the gun during movement operations. This includes all efforts associated with the design, development, integration, fabrication, assembly and test of the gun pointing subsystem.	
<b>WBS Element:</b> 13600	<b>WBS Title:</b> Turret Structure Subsystem
The Turret Structure Subsystem element refers to a load bearing component which provides the structural integrity to withstand the operational loading stresses generated while traversing various terrain profiles and firing the armament. This includes all efforts associated with the design, development, integration, fabrication, assembly and test of a complete SPH turret structure. It includes provisions to accommodate SPH subsystems. This element refers to all hardware items associated with providing onturret equipment encapsulation and structure. This element satisfies not only the structural requirements but also provides for primary ballistic protection. Included are structure, surface plates, frames, braces and other reinforcements for the ammunition and weapon compartments and appendages attached to the turret. Hardware includes items affixed to the turret structure for the purpose of lifting (e.g., lifting eyes) the SPH during production, transport, and vehicle recovery; items affixed to the structure needed to interface with the chassis structure; all hatches, doors, grilles, cupolas, plates, covers, guards, stowage racks and boxes. The turret structure WBS element includes the design, development, fabrication, assembly and integration of supplemental ballistic protection attachment approaches for external armor, liners and behind armor debris shielding. It also includes the design and integration of susceptibility and vulnerability reduction techniques into the turret structure design.	



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<b>WBS Element:</b> 13700	<b>WBS Title:</b> Armament Peripherals
The Armament Peripherals refers to support hardware associated with thermal conditioning and power distribution assemblies, and miscellaneous equipment required to accomplish the armament functions which are not included within any other armament level 4 WBS elements. Peripheral equipment to set fuze, track projectiles, and determine muzzle velocity, ram depth, projectile fallback, and bore clear are included. This element includes all efforts associated with the design, development, integration, fabrication, assembly, and test of the armament peripherals.	
<b>WBS Element:</b> 13710	<b>WBS Title:</b> Thermal Management Assemblies
The thermal management assemblies refer to the heat exchangers and peripheral equipment required by the propellant fill, lubrication delivery, damper supply and dousing assemblies and by the RLPG and gun mount subsystems. This element includes all efforts associated with the design, development, integration, fabrication, assembly and test of the thermal management hardware onboard the RLPG and gun mount subsystems.	
<b>WBS Element:</b> 13800	<b>WBS Title:</b> Position and Aiming Subsystem
The Primary Position and Aiming element subsystem refers to all hardware which permits the vehicle to locate its position and cannon aiming direction. This includes all efforts associated with the design, development, integration, fabrication, assembly, and test of primary position and aiming components.	
<b>WBS Element:</b> 13900	<b>WBS Title:</b> Armament Control Subsystem
The RLPG Armament Control Subsystem element refers to all electronic hardware and software which controls the loading, fluid handling, pointing and firing of the RLPG cannon. This includes controls to set fuze, track projectiles, and determine muzzle velocity, ram depth, projectile fallback, and bore clear. This element includes all efforts associated with the design, development, integration, fabrication, assembly, and test of armament control components.	
<b>WBS Element:</b> 13A00	<b>WBS Title:</b> Armament Program Management
The Armament/Program Management element refers to the business management of the armament element and projects. This WBS element encompasses the overall project management, subcontract management and overall planning and control (CS <sup>2</sup> ) of the armament element. This includes overall armament element project planning, budgeting, scheduling, performance analysis, and project cost/schedule reviews.	
<b>WBS Element:</b> 13B00	<b>WBS Title:</b> Armament System Engineering
The Armament System Engineering element refers to the technical management efforts of directing and controlling a totaling integrated Armament System development process. This element encompasses the systems engineering effort to define the Armament System and the integrated planning and control of the product development efforts of design engineering, specialty engineering, production engineering and integrated test planning.	
<b>WBS Element:</b> 13C00	<b>WBS Title:</b> Armament I,A,T&C
This effort includes all activities associated with the integration, assembly, test, and check out of the armament element. Included are all activities associated with the design, development, integration, fabrication, assembly, support and test of unique RLPG armament test equipment. This includes advanced technology demonstrator (ATD) and RLPG hardstands.	

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<b>WBS Element:</b> 14000	<b>WBS Title:</b> Ammo/Other Material Handling Equipment (A/O MHE)
The A/O MHE element refers to equipment, both hardware and software, providing the means to receive, store, prepare, select, transfer or download projectiles, propellant, fuel or other supplies. Ammo/other material handling equipment risk mitigation and component maturation activities are included in the product development function of this element. All effort associated to integrate A/O MHE with the remaining level 3 WBS elements and the integration, assembly, test and checkout of the A/O MHE elements into the Crusader is excluded.	
<b>WBS Element:</b> 14100	<b>WBS Title:</b> Projectile Storage and Transfer
The Projectile Storage and Transfer element refers to all hardware associated with fuzed projectile upload, storage, selection, transfer, identification, verification, weighing, marking, and download. It includes equipment interfaces to the docking and transfer element and provide the final azimuth position at the projectile loader. Design, development, integration, fabrication, assembly and testing relating to projectile storage and transfer are part of this element.	
<b>WBS Element:</b> 14200	<b>WBS Title:</b> Propellant Storage and Transfer
The Propellant Storage and Transfer element refers to all hardware required to perform the propellant storage and transfer functions with the SPH and RSV. Included are all efforts associated with propellant upload, storage, handling, selection, analysis, transfer, control, download, and disposal. The RSV portion of the task includes interfacing equipment necessary to upload from (Army) retail supply sources and distribute propellant to the docking and transfer element. This includes all efforts associated with the design, development, integration, fabrication, assembly and test of the propellant storage and transfer subsystem.	
<b>WBS Element:</b> 14300	<b>WBS Title:</b> Fuel Storage and Transfer
The Fuel Storage and Transfer element refers to all hardware required to receive, store and secure fuel within the RSV vehicle, interfacing equipment necessary to upload from (Army) retail supply sources and equipment to deliver fuel to SPH during the rearm process. This includes interfaces to the docking and transfer, engine, and armament fuel handling equipment elements. Design, development, integration, fabrication, assembly and testing efforts relating to fuel storage and transfer are included in this element. This element excludes LP, and other fluids storage and transfer.	
<b>WBS Element:</b> 14400	<b>WBS Title:</b> Docking and Transfer Subsystem
The Docking and Transfer element refers to all hardware required to physically link a RSV with an SPH or with another RSV in preparation for transfer of fuzed projectiles, propellant and/or fuel. This includes accesses and equipment necessary for transfer of the above items between the RSV and ground equipment. Also included are the data and power links between vehicles. Design, development, integration, fabrication, assembly and testing efforts relating to docking and transfer are part of this element.	
<b>WBS Element:</b> 14500	<b>WBS Title:</b> Other Supplies, Storage and Transfer Equipment
The Other Supplies, Storage and Transfer Equipment element refers to all hardware required to receive supplies other than fuzed projectiles, liquid propellant, and fuel onto the RSV from a flatrack, SPH, RSV, truck or the ground. The RSV must then be able to handle and store these supplies, select and deliver them to an SPH or RSV. This includes the design, development, integration, fabrication, assembly and testing of this element.	

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<b>WBS Element:</b> 14600	<b>WBS Title:</b> Ammunition Processing and Upload Equipment
The Ammunition Processing and Upload Equipment element refers to all hardware and software required to depalletize projectiles, install fuzes, prepare a fuzed projectile for use by the A/O MHE functional element and transfer projectiles to the RSV from a flatrack, truck or the ground. This includes all efforts associated with the design, development, integration, fabrication, assembly and test of this element.	
<b>WBS Element:</b> 14700	<b>WBS Title:</b> A/O MHE Controls
The A/O MHE Controls element refers to all hardware and software which controls the projectile, propellant and fluid transfer functions, the docking and transfer subsystem, and other functions within the A/O MHE functional element requiring automated operation. This element includes all efforts associated with the design, development, integration, fabrication, assembly, and test of A/O MHE controls.	
<b>WBS Element:</b> 14800	<b>WBS Title:</b> RSV Enclosure Subsystem
The RSV Enclosure Subsystem element refers to all efforts associated with the design, development, integration, fabrication, assembly, test and checkout of the mission equipment subsystem to include the mission equipment structure assembly, and appendages. The RSV mission equipment structure refers to the vehicle structure above the sponsons which supports, encloses and provides primary ballistic protection to the RSV mission equipment. This includes all efforts associated with the design, development, integration, fabrication, assembly and test of a complete RSV mission equipment structure. This assembly refers to all hardware items associated with providing mission equipment encapsulation and structure. The RSV Enclosure Subsystem WBS element includes design, development, fabrication, assembly and integration of supplemental ballistic protection attachment approaches for external armor, liners and behind armor debris shielding. The mission equipment structure assembly includes structure, surface plates, frames, braces and other reinforcements for the mission equipment as well as any appendages attached to it. Appendages include items affixed to the mission equipment structure such as hatches, doors, grilles, plates, covers, guards, stowage racks and boxes, other appendages, and bearing support structure. All effort directly associated with the remaining level 3 WBS elements and the integration, assembly, test and checkout of these elements into the RSV is excluded.	
<b>WBS Element:</b> 14900	<b>WBS Title:</b> A/O MHE Peripherals
The A/O MHE Peripherals element refers to the all hardware and software associated with thermal and electrical power subsystems and miscellaneous equipment. This element includes all efforts associated with the design, development, integration, fabrication, assembly, and test of A/O MHE peripherals.	
<b>WBS Element:</b> 14A00	<b>WBS Title:</b> A/O MHE Program Management
The A/O MHE program management element refers to the business management of A/O MHE and associated projects. This WBS element encompasses the project management, subcontract management, and overall planning and control(CS <sup>2</sup> ) of A/O MHE.	
<b>WBS Element:</b> 14B00	<b>WBS Title:</b> A/O MHE System Engineering
The A/O MHE element refers to the technical management efforts of directing and controlling a totally integrated A/O MHE development process. This element encompasses the systems engineering effort to define the A/O MHE and the integrated planning and control of the product development efforts of design engineering, specialty engineering, production engineering and integrated test planning.	
<b>WBS Element:</b> 14C00	<b>WBS Title:</b> A/O MHE I,A,T&C
The A/O MHE Element I, A, T&C includes all activities associated with the integration, assembly, test and check out of the A/O MHE element. Included are all activities associated with the design, development, integration, fabrication, assembly, support and test of unique Resupply test equipment.	

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<b>WBS Element:</b> 15000	<b>WBS Title:</b> Command, Control, Communications and Crew (C3 and Crew)
<p>The C3 and Crew element refers to all hardware and software providing command, control, communications, or crew support functions. Included in this element are fire control sights, tactical and technical fire control equipment, DA fire control equipment, data display and controls, decision aids, video distribution and control, interlocation and intravehicle communications, and identification and navigation subsystem. Command, control, communications and crew risk mitigation and component maturation activities are included in the product development function of this element. All effort associated to integrate C3 and Crew with the remaining level 3 WBS elements and the integration, assembly, test and checkout of the C3 and Crew elements into the Crusader is excluded.</p>	
<b>WBS Element:</b> 15100	<b>WBS Title:</b> Fire Control Sights Subsystem
<p>The Fire Control Sights Subsystem element refers to all hardware and software which provides local aim point identification, tracking and computation necessary for accurate primary armament pointing in a direct fire mode or indirect fire mode using a distant line of sight aim point method to lay on the target. This element includes, for example, fire control sights or scopes, range finders, and computer programs. All efforts directly associated with the remaining level 4 WBS elements and the integration, assembly, test and checkout of these elements into higher levels of assembly is excluded.</p>	
<b>WBS Element:</b> 15200	<b>WBS Title:</b> Tactical/Technical Fire Control
<p>The Tactical and Technical Fire Control (TTFC) element refers to the capability of the C3 and Crew functional element to receive, store, manage, compute and provide to the PA functional element the technical fire control information necessary to execute fire missions.</p> <p>TTFC supports C3 with fire direction computation in assessment of system ability to support indirect fire missions from current or proposed firing positions.</p> <p>Tactical fire control includes all considerations required to determine if, how, in what priority, and when to attack a target. Technical fire control includes consideration of all computational factors affecting accuracy of indirect fire to the point of determining gun azimuth, elevation, muzzle velocity, and time to fire (includes applying meteorological, registration, and PTS corrections if used).</p> <p>Technical fire control includes all considerations, and calculations required to preclude violations of safety restrictions, intermediate crests or masks.</p> <p>TTFC receives, stores, assesses, and updates fire plans.</p> <p>TTFC advises the crew through collaboration with Data Displays and Controls during execution of indirect fire missions.</p>	
<b>WBS Element:</b> 15300	<b>WBS Title:</b> Defensive Armament Fire Control
<p>The DA Fire Control element refers to all hardware and software which provides intelligence necessary for integration of crew data displays and controls with the defensive armament weapons pointing and delivery. This element includes for example, any software required to translate true azimuth and vertical angle or crew commands from a joystick into executable pointing commands for the defensive armament. DA fire control includes hardware (other than the displays and controls) and software required to process and send crew commands to load, arm, fire, clear, or interrupt defensive armament.</p>	



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<b>WBS Element:</b> 154000	<b>WBS Title:</b> Data Display and Controls (DD and C)
<p>The DD and C element displays the necessary operational and tactical information to the crew for efficient management of the Crusader during all segments of the mission profile under day and night, all-weather conditions. It includes all hardware and software needed for the crew to receive information regarding Crusader system operations and status of the vehicle and its functions, as well as all hardware and software which enable the crew to control the vehicle functions.</p> <p>DD and C provides the crew battle station hardware and software required for crew control, as defined in interface control documents, over armament, ammunition handling, automotives, survivability, and communications subsystems. DD and C provides the interface between the crew and decision aids.</p> <p>DD and C includes hardware and software required to exercise central control over configuration and coordination between elements to execute operations.</p> <p>DD and C provides the crew environment ( not including air conditioning and filtration) with crew support equipment such as vision devices (except cameras) seats restraints, interior lighting, personal hygiene facilities, ration/water heater, etc. DD and C provides stowage for crew gear inside the crew compartment. DD and C provides ingress and egress accommodations inside the crew compartment.</p>	
<b>WBS Element:</b> 15500	<b>WBS Title:</b> Tactical C3
<p>The Tactical C3 element includes all hardware and software required to conduct tactical and technical planning and to analyze up-to-date intelligence and current technical situations. The Tactical C3 function is to assist the crew in conducting RSOP (reconnaissance, self and occupation of position), self-defense, sustainment, technical situation assessment, and technical planning.</p> <p>Tactical C3 includes a segment level tactical decision making function which schedules vehicle operations, sets segment priorities, establishes requirements and constraints for technical plans, establishes criteria for when to initiate a planned operation, and collaborates with DD and C to involve the crew in system level command and control.</p> <p>Tactical C3 provides route planning, resupply/upload planning, and survivability planning decision support. Tactical C3 provides awareness of a FA support plan extract for Crusader operations, a terrain analysis capability, and a battlefield entity analysis capability.</p> <p>Tactical C3 provides information to advise the crew during execution of segment operations and control of the elements. Tactical C3 records useful historical information for recollection such as the communications log, and records of fire.</p> <p>Tactical C3 support the crew in planning for maintenance and training.</p>	
<b>WBS Element:</b> 15600	<b>WBS Title:</b> Video Distribution and Control (VD& C)
<p>The VD&amp;C element refers to the electronic devices, cabling, hardware and embedded software used to collect, process and distribute all vehicle video signaling intended for use by the vehicle crew. Excluded are video devices and sensors used for special functions where the video image is not displayed to the crew.</p>	
<b>WBS Element:</b> 15700	<b>WBS Title:</b> Interlocation Communications
<p>The Interlocation Communications element refers to all hardware which accomplishes the external communication functions. This includes all efforts associated with the design, development, integration, test and assembly of the interlocation communications components.</p>	

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<b>WBS Element:</b> 15800	<b>WBS Title:</b> Intravehicle Communications
The Intravehicle Communication element refers to all hardware which accomplishes the internal communication functions and communication with person(s) located outside but in close proximity to the Crusader. This includes all efforts associated with the design, development, integration, test and assembly of the intravehicle communications components.	
<b>WBS Element:</b> 15900	<b>WBS Title:</b> Identification - Friend or Foe
The Identification - Friend or Foe element refers to all hardware and software which accomplishes the detection/determination of friend or foe function in order to prevent friendly systems from inadvertently engaging and damaging/killing one another. Device(s) may be either cooperative (requiring interrogation and response to/from each platform) or non-cooperative (requiring no exchange of information between platforms). This includes all efforts associated with the design, development, integration, fabrication, assembly, and test of ID-friend or foe components.	
<b>WBS Element:</b> 15A00	<b>WBS Title:</b> Navigation Subsystem
The Navigation Subsystem element refers to all hardware and/or software which permits the crew to determine vehicle location and to plot the course of the vehicle. It includes navigation systems such as dead reckoning, inertial and global positioning systems. Landmark recognition algorithms and processors (if used) are also included. It may also include data displays when they are not integral with the Data Display and Control. This includes all efforts associated with the design, development, integration, test and assembly of the navigation subsystem element. The navigation subsystem includes software and hardware required to analyze and determine position and orientation of off board entities or terrain features. The navigation subsystem includes software and hardware required to advise the crew on execution of movement plans through the data displays and controls.	
<b>WBS Element:</b> 15B00	<b>WBS Title:</b> C3 and Crew Program Management
The C3 and Crew Program Management element refers to the business management of C2 and Crew and associated projects. This WBS element encompasses the project management, subcontract management, and overall planning and control (CS <sup>2</sup> ) of C3 and Crew Program Management.	
<b>WBS Element:</b> 15C00	<b>WBS Title:</b> C3 and Crew System Engineering
The C3 and Crew System Engineering element refers to the technical management efforts of directing and controlling a totally integrated C2 and Crew System development process. This element encompasses the systems engineering effort to define the C3 and Crew Program and the integrated planning and control of the project development efforts of design engineering, specialty engineering, production engineering and integrated test planning.	
<b>WBS Element:</b> 15D00	<b>WBS Title:</b> C3 and Crew Element I,A,T&C
The C3 and Crew I, A, T&C element includes all activities associated with the integration, assembly, test, and check out of the C3 and Crew element. Included are all activities associated with the design, development, integration, fabrication, assembly, support and test of C3 and Crew.	

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<b>WBS Element:</b> 16000	<b>WBS Title:</b> Vehicle Electronics
<p>The Vehicle Electronics element refers to all effort required to analyze, design, develop, fabricate, assemble, integrate, and checkout the Crusader Vehicle Electronics System. This includes hardware and software to coordinate, control, and support the Crusader mission subsystem operations. Related equipment includes core processing units, sensor and actuator interface units, servo-amplifier units, digital data communications network(s) interconnecting these units, power conditioning, distribution and control equipments. This element includes the operating system software, application management and support services and the overall control system executive. The vehicle electronics function provides the data processing assets used by the other elements to perform their software controlled functions. This element provides the interface and conveyance of sensor and actuator signaling, data collection and logging facilities, the general purpose processing equipment and software services for the other elements. Vehicle electronics risk mitigation, information vulnerability reduction and component maturation activities are included in the product development function of this element. Hardware and software integral to specific WBS level 3 subsystems, or related to other WBS level 2 elements are excluded from the vehicle electronics element.</p>	
<b>WBS Element:</b> 16100	<b>WBS Title:</b> Data Distribution and Control Subsystem
<p>The Data Distribution and Control Subsystem element refers to the network of communication links between the SPH vehicle control system units. It is the data communications set used to convey digital data between Crusader core computing units, sensor interface units and actuator interface units. This element includes the analysis, design, fabrication, assembly and test of the media/computer interface hardware and the embedded media interface control software.</p>	
<b>WBS Element:</b> 16200	<b>WBS Title:</b> Power Distribution and Control Subsystem
<p>The Power Distribution and Control Subsystem element refers to the set of equipments used to store, distribute, condition and control electrical power provided by the power generation source(s) and distributed to each Crusader control system unit within the vehicle electronics suite and each Crusader element. This element shall perform branch circuit management, over-current control, line disturbance filtering, circuit operation monitoring, and power storage. This element includes the analysis, design, fabrication and test of the Crusader component sets.</p>	
<b>WBS Element:</b> 16300	<b>WBS Title:</b> System Computing Resources
<p>The Computing Resources element refers to the computer processor module of the core processor units. The computing resource is the general purpose processing asset of the Vehicle Electronics element. This element includes the analysis, design, fabrication and test of the Crusader sets.</p>	
<b>WBS Element:</b> 16400	<b>WBS Title:</b> Operating System and Services/Executive
<p>The Operating System and Services/Executive element refers to the software that provides the operating environment in which software application using system core processing units are managed. The services provided by this element include the management of software processes, the management of processing assets, the management of intravehicle digital communications using the data distribution and control subsystem, the management of intravehicle video communications using the video distribution and control subsystem, mass memory management, data storage and distribution management and common utility (e.g. math or data structures) software. The operating system and services/executive subsystem controls the data distribution and control, the power distribution and control, the system computing resources and the video distribution and control subsystems. The element provides the interface software to other Crusader elements employing the data distribution and control subsystem.</p>	

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WBS Element: 16500	WBS Title: Vehicle Electronics Peripherals
<p>The Vehicle Electronics Peripherals element refers to the effort required to develop vehicle electronics packaging, system cabling, servo-amplifiers, mass memory device, sensor/actuator interface electronics and other miscellaneous equipments as described below. This element includes the analysis, design, fabrication and test of each of the described component sets.</p> <p><b>Electronics Packaging:</b> The Vehicle Electronics Packaging element refers to the effort required to ensure that vehicle electronics components meet space and weight requirements while preserving adequate thermal management and electromagnetic interference control. This element includes the necessary analyses and system modeling support activities for system thermal modeling, system electromagnetic interference/electromagnetic compatibility (EMI/EMC) modeling, electronics enclosure design and placement within the SPH and RSV vehicles.</p> <p><b>System Cabling:</b> The System Cabling element refers to the effort required to ensure that the overall cabling, routing and clamping, and harness integration are consistent across the cabling set and in compliance with the EMI/EMC, signaling and power distribution requirements of the system.</p> <p><b>Servo-Amplifiers:</b> The Servo-Amplifier element refers to the electrical power control components (hardware and software) of electric motor controlled servo-mechanisms. This element includes the interface definition of the low level signaling, the servo-controlled loop sensor components, and the interface between the amplifier unit and the motor. This element shall ensure that the servo-amplifier set meets space, weight, and power requirements while preserving adequate thermal management and electromagnetic interference control.</p> <p><b>Mass Memory Device:</b> The mass memory device (MMD) element refers to the storage and retrieval system (hardware and software) used to provide mass non-volatile memory capability for the system. This element includes the storage and retrieval capability for the system software programs, data, data logging, and digital map databases.</p> <p><b>Sensor/Actuator Interface Unit (SAIU):</b> The SAIU element refers to the electronics and software used to provide the transition between sensors and actuators (excluding servo-motors) and the digital data distribution subsystem. This element shall organize and functionally partition standard sensor and actuator interface signaling sets and develop an optimum group of interface modules from which individual SAIUs can be configured.</p> <p><b>Core Processing Unit (CPU):</b> The CPU element refers to the electronics and software used to provide the data processing assets of the vehicle electronics system. This element shall organize and functionally partition standard data processing component sets and develop an optimum group of modules from which individual CPU's can be configured. This element includes the backplane, memory, and power supply modules and the internal wiring of the unit into which the Computing Resource module, Data Distribution and Control network interface module, Video Distribution and Control processing and network interface modules, and special purpose processing modules are used.</p>	



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<b>WBS Element:</b> 16600	<b>WBS Title:</b> Vehicle Electronics Program Management
The Vehicle Electronics program management element refers to the business management of Vehicle Electronics and associated projects. This WBS element encompasses the project management, subcontract management, and overall planning and control (CS <sup>2</sup> ) of Vehicle Electronics.	
<b>WBS Element:</b> 16700	<b>WBS Title:</b> Vehicle Electronics System Engineering
The Vehicle Electronics element refers to the technical management efforts of directing and controlling a totally integrated Vehicle Electronics development process. This element encompasses the systems engineering effort to define Vehicle Electronics and the integrated planning and control of the product development efforts of design engineering, specialty engineering, production engineering and integrated test planning.	
<b>WBS Element:</b> 16800	<b>WBS Title:</b> Vehicle Electronics I,A,T&C
<p>WBS: The Vehicle Electronics Integration, Assembly, Test, and Checkout element refers to the effort required to integrate the Electronics System Set as a product. This includes Electronics element development and analysis, integration, test and checkout.</p> <p>ELEMENT DEVELOPMENT AND ANALYSIS: The Electronics Element Development and Analysis refers to all effort required for the Electronics System Architecture development and Electronics System Set design, development and fabrication activities required for the Integration, Assembly, Test and Checkout activities. This includes the organization of and collaboration with the PDT activities which use and/or interface with the Electronics System Set, e.g., sizing for power, power control, sizing for processor time, sizing for program and data memory, and data and signaling interface definition including, throughput loading, source/destination and timing.</p> <p>ELEMENT INTEGRATION: The Element Integration refers to all efforts required to integrate and assemble the Electronics subsystems into the Electronics System Set. This includes the design and fabrication of fabrication fixtures and fabrication support software, development and documentation of fabrication processes and specifications, and the procurement of the equipment and material for the Electronics System Sets and their integration.</p> <p>ELEMENT TEST AND CHECKOUT: The Element Test and Checkout refers to all effort to develop Electronics element subsystem integration test plans, procedures and test reports. The conduct of test and checkout activities in accordance with the program Master Test Plan to verify that the assembled Electronics element performs to the requirements of the Crusader system specification and the Electronics PIDS.</p>	
<b>WBS Element:</b> 17000	<b>WBS Title:</b> Survivability Suite
The Survivability Suite element refers to all hardware and software required to maximize the survivability of the Crusader vehicles and crew. This includes NBC and environmental control, supplemental ballistic protection, non-ballistic protection, fire suppression and defensive armament(s) and controls. Survivability suite risk mitigation and component maturation activities are included in the product development function of this element. All effort associated to integrate the survivability suite with the remaining level 3 WBS elements and the integration, assembly, test and checkout of the survivability suite elements into the Crusader is excluded.	

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<b>WBS Element:</b> 17100	<b>WBS Title:</b> NBC and Environmental Control
<p>The NBC and Environmental Control element refers to those subassemblies or components which provide NBC collective protection and environmental control to the vehicle crew, either individually or collectively, during a nuclear, biological, chemical attack and may provide environmental control to the crew under non-NBC warfare conditions. This may include a positive (over) pressure control system, a micro-climate cooling air conditioning system, a macro-climate cooling (air conditioning) system, an air purification system for both micro and macro-climate, ventilated face piece (mask), NBC detection and warning devices, decontamination kits, chemical resistant coatings, a ventilation subsystem with particulate filtration, NBC Contamination Survivability (NBCCS) features (hardening/compatibility/decontamination) and micro-climate control for crew members required to dismount during resupply operations. All effort directly associated with the remaining level 4 WBS elements and the integration, assembly, test and checkout of these elements into the Crusader is excluded.</p>	
<b>WBS Element:</b> 17200	<b>WBS Title:</b> Supplemental Ballistic Protection
<p>The SPH SBP element refers to all add-on penetration avoidance (ballistic protection) above and beyond that afforded by the basic vehicle housing and structure. Also included are all efforts associated with the design, fabrication, integration and assembly of the supplemental ballistic protection.</p>	
<b>WBS Element:</b> 17300	<b>WBS Title:</b> Non Ballistic Protection
<p>The Non Ballistic Protection element refers to all hardware and software providing the early warning, detection avoidance, acquisition/hit avoidance and selected kill/damage/degradation avoidance functions to reduce system and crew susceptibility and vulnerability. Included in this element are early warning against personnel, vehicular and air attacks; detection avoidance against radars, acoustic/seismic sensors, infrared sensors, millimeter wave sensors, and man-in-the-loop visual systems; acquisition/hit avoidance against overmatching smart munitions and kill/damage/degradation avoidance against explosive forces, fragments, fratricide, toxic materials, blast overpressure, nuclear events, directed energy and electromagnetic environmental effects. Also included are all efforts associated with the design, fabrication, integration and assembly of non-ballistic protection.</p>	
<b>WBS Element:</b> 17400	<b>WBS Title:</b> Fire Suppression
<p>The Fire Suppression element refers to all hardware and software associated with detecting, extinguishing and preventing the spontaneous re-ignition of multiple onboard fires. Also included are all efforts associated with the design, fabrication, integration and assembly of fire suppression for the crew, weapon and engine compartments.</p>	
<b>WBS Element:</b> 17500	<b>WBS Title:</b> Defensive Armament(s) (DA)
<p>The DA element refers to a means to deliver direct fire for self-defense at close-combat range exclusive of the survivability suite. This element includes, for example, the weapon, weapon mount, peripheral equipment, computer hardware and software and associated equipment. Fire control is not included. All effort directly associated with the remaining level 4 WBS elements and the integration, assembly, test and checkout of these elements into the survivability suite is excluded.</p>	
<b>WBS Element:</b> 17600	<b>WBS Title:</b> DA Control Subsystem
<p>The DA Control Subsystem element refers to all hardware/software which provides intelligence necessary for defensive armament weapons delivery such as launching and firing. This element includes controls and display screens external to the DD&amp;C element, sights, scopes, range finders, computers, computer programs, defensive armament mount, weapon drives and stabilization systems and sensors necessary for search, recognition and/or tracking (excluding surveillance sensors).</p>	

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<b>WBS Element:</b> 17700	<b>WBS Title:</b> Survivability Suite Program Management
The Survivability Suite Program Management element refers to the business management of the Survivability Suite System and associated projects. This WBS element encompasses the project management, subcontract management, and overall planning and control (CS <sup>2</sup> ) of the Survivability Suite Program Management.	
<b>WBS Element:</b> 17800	<b>WBS Title:</b> Survivability Suite System Engineering
The Survivability Suite System Engineering element refers to the technical management efforts of directing and controlling a totally integrated Survivability Suite System development process. This element encompasses the systems engineering effort to define the Survivability Suite System and the integrated planning and control of the product development efforts of design engineering, specialty engineering, production engineering and integrated test planning.	
<b>WBS Element:</b> 17900	<b>WBS Title:</b> Survivability Suite I,A,T&C
The Survivability Suite I, A, T&C element includes all activities associated with the integration, assembly, test, and check out of the Survivability Suite System element. Included are all activities associated with the design, development, integration, fabrication, assembly, support and test of the Survivability Suite System.	
<b>WBS Element:</b> 18000	<b>WBS Title:</b> Automotives
The Automotives element refers to all hardware and software associated with the structure, suspension and propulsion of the Crusader. This includes auxiliary systems and controls necessary to provide a safe, operable, testable automotives element. Automotives risk mitigation and component maturation activities are included in the product development function of this element. All effort associated to integrate the automotives functional element with the remaining level 3 WBS elements and the integration, assembly, test and checkout of the automotives elements into the Crusader is excluded.	
<b>WBS Element:</b> 18100	<b>WBS Title:</b> Hull Structure Subsystem
The Hull Structure Subsystem element refers to all efforts associated with the design, development, integration, fabrication, assembly, test and checkout of the hull structure/armor subsystem to include the hull structure, ballistic protection provided by the basic hull structure, bearing ring support structure and hull appendages. It includes provisions to accommodate all other subsystems mounted in the hull and the firepower element which will be attached to the bearing ring support structure of the hull, as well as any appendages which attach directly to the primary structure. Appendages include items affixed to the hull structure for the purpose of lifting the vehicle during production, transport and vehicle recovery; items associated with encapsulating crew, power package/drive train and on-vehicle equipment; items affixed to the hull structure needed to tow trailers, tow similar vehicles and interface with vehicle retrievers; and all hatches, vision blocks, doors, grilles, fenders, skirts plates, covers, guards, storage racks, boxes and other appendages except RSV unique and bearing support structure. This assembly refers to all hardware items associated with providing crew and onhull equipment encapsulation and structure. This element satisfies not only the structural requirements but also provides for primary ballistic protection. The hull structure WBS element includes design, development, fabrication, assembly and integration of supplement ballistic protection attachment approaches for external armor, liners and behind armor debris shielding. It also includes the design and integration of susceptibility and vulnerability reduction techniques into the hull design.	

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<b>WBS Element:</b> 18200	<b>WBS Title:</b> Suspension
<p>The Suspension element refers to the means for generating, controlling and applying tractive efforts, controlling thrust, lift, and steering forces and adapting the vehicle to irregularities of the surface. This element includes wheels, tracks, and steering gears for traction and control functions. It also includes springs, shock absorbers, and other suspension members. This includes all efforts associated with the design, development, fabrication, assembly, integration and test of suspension and steering assemblies. Steering, if integral to power transmission, may be included under WBS element Power Package/Drive Train (PP/DT). All effort directly associated with the remaining level 4 WBS elements and the integration, assembly, test and checkout of these elements into the automotives functional element is excluded.</p>	
<b>WBS Element:</b> 18300	<b>WBS Title:</b> Power Package/Drive Train
<p>The PP/DT element refers to the means for generating power and delivering it in the required quantities and driving rates to the driving member as well as providing power for all vehicle components. This element includes for example, PP/DT auxiliaries such as air ducting, manifolds, air cleaners, controls, instrumentation, exhaust systems, fuel systems (excluding resupply unique fuel handling system), and cooling means for automotive components. It also includes such power transport components as clutches, transmission, shafting assemblies, torque converters, differentials, final drives, and power takeoffs. It may include steering and braking if it is integral to power transmission rather than in the suspension/steering element. All effort directly associated with the remaining level 4 WBS elements and the assembly, integration, test and checkout of these elements into the automotive functional element is excluded.</p>	
<b>WBS Element:</b> 18400	<b>WBS Title:</b> Automotives Auxiliary Systems
<p>The Automotives Auxiliary Systems element refers to the group of subsystems (hardware and software) which provide services to automotives subsystems, as distinguished from the special equipment subsystems. This element includes, for example, the mobility and mission equipment subsystems, such as system: electrical, auxiliary power, hydraulics, and accessories such as exterior lighting (i.e., headlights, taillights, blackout light markers). This includes all efforts associated with the design development, fabrication, assembly, integration and test of the automotives auxiliary systems. All effort directly associated with the remaining level 4 WBS elements and the integration, assembly, test and checkout of these elements into the functional element is excluded.</p>	
<b>WBS Element:</b> 18500	<b>WBS Title:</b> Automotives Controls
<p>The Automotives Controls element refers to all hardware and software which controls the automotive subsystems other than those that are part of the vehicle electronics architecture. This includes sensors, electronics, cabling and software integrated with individual assemblies to permit local start-up and operation to include ground hop operation. This element includes all efforts associated with the design, development, fabrication, assembly, integration and test of automotives controls.</p>	
<b>WBS Element:</b> 18600	<b>WBS Title:</b> Automotives Program Management
<p>The Automotives Program Management element refers to the business management of the Automotives Program and associated projects. This WBS element encompasses the project management, subcontract management, and overall planning and control (CS<sup>2</sup>) of the Automotives Program.</p>	



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<b>WBS Element:</b> 18700	<b>WBS Title:</b> Automotives System Engineering
The Automotives System Engineering element refers to the technical management efforts of directing and controlling a totally integrated Automotives System development process. This element encompasses the systems engineering effort to define the Automotives Program and the integrated planning and control of the product development efforts of design engineering, specialty engineering, production engineering and integrated test planning.	
<b>WBS Element:</b> 18800	<b>WBS Title:</b> Automotives Element I,A,T&C
This WBS element encompasses the overall integration of the Automotives element. This WBS includes all efforts required to plan, analyze, integrate, assembly, test and check out the level 4 WBS elements into a fully functional Automotives element (i.e., ATRs and prototypes). This includes design and fabrication of fabrication fixtures, development and documentation of fabrication processes and specifications and procurement of equipment and materials for Automotives functional element integration. This WBS include reliability and performance testing of the Automotive Test Rigs (ATRs) and check out of the SPH and RSV prototype chassis.	
<b>WBS Element:</b> 20000	<b>WBS Title:</b> System Test and Evaluation (ST&E)
The ST&E element refers to the use of prototype, and/or specially fabricated hardware/software to obtain or validate engineering data on the performance of the SPH, RSV segments individually, and/or the Crusader as a complete and integrated system, as well as any integration and test of SPH or RSV components when conducted as an other than complete system test to verify system level requirements. These system tests are formal tests such as EDT, EUT, FDT&E and Logistics Demonstration. This element includes the detailed planning, conduct, support, data reduction and reports from such testing, and all hardware/software items which are consumed or planned to be consumed in the conduct of such testing. Included are all verification efforts and methods (e.g., design analysis, simulation, inspection, demonstration, test and system effectiveness evaluations) for: (a) verifying design requirements, physical architecture and physical interfaces to ensure functional and performance requirements are satisfied; (b) evaluating the system to verify it meets functional, performance and design requirements as well as customer needs/requirements; and (c) verifying that product, process and manufacturing designs satisfy identified needs and customer requirements. It also includes all effort associated with the design and fabrication of models, specimens, fixtures, and instrumentation in support of the system level test program.	
<b>WBS Element:</b> 21000	<b>WBS Title:</b> Development Test
The development test element refers to that test and evaluation conducted to: (a) demonstrate that the engineering design and development process is maturing as planned; (b) demonstrate that the design risks have been minimized; (c) demonstrate that the system will meet prototype specifications; (d) estimate the system's military utility when introduced; (e) determine whether the engineering design is supportable (practical, maintainable, safe, etc.) for operational use; (f) provide test data with which to examine and evaluate tradeoffs against prototype specification requirements, life cycle cost, and schedule; and (g) perform the logistics testing efforts to evaluate the achievement of supportability goals, the adequacy of the support package for the system, (e.g. deliverable maintenance tools, test equipment, technical publications, maintenance instructions, and personnel skills and training requirement, etc. ).	

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<b>WBS Element:</b> 22000	<b>WBS Title:</b> Operational Test
The Operational Test element includes contractor support (e.g., technical assistance, maintenance, labor, material, etc.) consumed during this phase of testing. Included are such test activities as: weapons evaluation, operator and maintenance instructions, crew/vehicle interface, supportability verification, suitability testing, and effectiveness testing. Operational tests are conducted by agencies other than the developing command to assess the prospective system's military utility, operational effectiveness, operational suitability, logistics supportability (including compatibility, interoperability, reliability, maintainability, logistics requirements, etc.), cost of ownership, and need for any modifications. Initial Operational Test and Evaluation (IOT&E) conducted during the development of a weapon system will be included in this element.	
<b>WBS Element:</b> 23000	<b>WBS Title:</b> Mock-ups
The Mock-Ups element refers to the design engineering and production of system or subsystem mock-ups which have special engineering significance, or which are not required solely for the conduct of one of the above elements of testing. This effort excludes any models developed and fabricated required solely for the conduct of operational or developmental testing WBS elements.	
<b>WBS Element:</b> 24000	<b>WBS Title:</b> ST&E Support
The ST&E Support element refers to all support elements necessary to operate, maintain, refurbish and upgrade systems and subsystems during test and evaluation which are not consumed during the testing phase. This element includes, for example, repairable spares, repair of repairables, repair parts, warehousing and distribution of spares and repair parts, test and support equipment, test instrumentation, test ammunition and targets, test bed vehicles, drones, surveillance vehicles, tracking vehicles, contractor technical support, etc. Operator and maintenance personnel, consumables, special fixtures, special instrumentation, etc., which are utilized and/or consumed during lower level testing and which should therefore be included under that element of testing are excluded.	
<b>WBS Element:</b> 25000	<b>WBS Title:</b> ST&E Facilities and Resources
The ST&E Facilities and Resources element refers to those special test facilities and resources required for performance of the various tests necessary to prove the design and reliability of the system or subsystem. Included are such items as an environmental lab. The brick and mortar-type facilities identified as industrial facilities are excluded.	
<b>WBS Element:</b> 30000	<b>WBS Title:</b> System Engineering/Program Management
The System Engineering/Program Management element refers to the systems engineering, modeling and simulation, diagnostics and prognostics and technical control as well as the business management of Crusader segments and projects. This element encompasses the overall planning, directing and controlling of the definition, development and production of a segment or project, including functions of logistics engineering and integrated logistics support (ILS) management, e.g. maintenance support, facilities, personnel, training, testing and activation of a system. Crusader System Engineering/Program Management effort that can be associated specifically with the equipment (hardware/software) element is excluded.	

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<b>WBS Element:</b> 31000	<b>WBS Title:</b> System Engineering
<p>The Systems Engineering element refers to the technical and management efforts of directing and controlling a total integrated effort of the Crusader program. This element encompasses the systems engineering effort to define the system and the integrated planning and control of the technical program efforts of design engineering, specialty engineering, production engineering and integrated test planning. This element includes, but is not limited to: the systems engineering effort to transform an operational need or statement of deficiency into a description of system requirements and a preferred system configuration; and the technical planning and control effort for planning, monitoring, measuring, evaluating, directing and replanning the management of the technical program. Specialty functions and subordinate programs of particular interest include life cycle cost/design to cost, testability engineering, logistic support analysis (LSA), training analysis, MANPRINT, hazardous material/environmental management program, parts control program, standardization program, producibility, product assurance, system security, technical performance measures and development of engineering data at the Crusader, SPH and RSV levels.</p> <p>Detailed system engineering activities include the following:</p> <ul style="list-style-type: none"> <li>• perform mission analysis,</li> <li>• develop and evaluate operational and system concepts,</li> <li>• establishing and reviewing system requirements,</li> <li>• maintain and manage a current requirements traceability system,</li> <li>• prepare, review and evaluate specifications,</li> <li>• perform system sizing and sensitivity analyses,</li> <li>• conduct system and segment level trade studies,</li> <li>• define a viable system configuration,</li> <li>• conduct preliminary system analysis and identify control parameters,</li> <li>• allocate functional elements to segment and subsystem levels,</li> <li>• select baseline configuration,</li> <li>• verify capability at system level,</li> <li>• maintain IMP and IMS to current task definition.</li> </ul> <p>Also included in this task are program level systems engineering efforts such as maintaining and updating the systems engineering management plan (SEMP). System engineering activities at the subsystem level extend the products of system level system engineering to the functional elements and consist of similar activities.</p> <p>This WBS element specifically excludes the actual design engineering and the production engineering directly related to the WBS element with which it is associated.</p>	
<b>WBS Element:</b> 31100	<b>WBS Title:</b> Crusader System Engineering
<b>WBS Element:</b> 31200	<b>WBS Title:</b> Combat Vehicle Segment System Engineering
<b>WBS Element:</b> 31300	<b>WBS Title:</b> Support Segment System Engineering
<b>WBS Element:</b> 31400	<b>WBS Title:</b> Training Segment System Engineering

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<b>WBS Element:</b> 31500	<b>WBS Title:</b> Industrial Segment System Engineering
<b>WBS Element:</b> 31600	<b>WBS Title:</b> Crusader System Integration
This element refers to the design, acquisition and/or construction, and operation/maintenance of the physical equipments and facilities to support the integration, assembly, test and checkout activities for the SPH and RSV demonstrator and prototype vehicle combat systems as characterized in WBS elements 11000 and 12000.	
<b>WBS Element:</b> 31610	<b>WBS Title:</b> System Integration Laboratory (SIL)
This element refers to the requirements definition, design and build of System Integration Laboratory (SIL) facility capable of supporting simulations, modeling, virtual prototyping, force effectiveness evaluations, hardware and software integration, System Level Integration Demonstrators (SLID) and Distributed Interface Simulation (DIS) interface with Battle Lab(s) and other remote facilities. It includes the provision of facilities and environmental support equipment, special tools and test equipment, simulators and stimulators, and software upload/download/debug equipments. It also includes the operation and maintenance of the SIL facilities and equipments.	
<b>WBS Element:</b> 31700	<b>WBS Title:</b> Crusader System Modeling and Simulation
<p>The System Modeling and Simulation element refers to the design, development, fabrication, evaluation and demonstration of weapon system capabilities via computer modeling, manned and unmanned simulators, virtual prototyping and Battle Lab interaction. Battle Lab work will perform experiments, measure system effectiveness and assess battlefield processes, procedures and conditions in a virtual environment through Distributive Interactive Simulation (DIS). Computer modeling activities refer to the development of three dimensional, solid model, computer based visualization tools ( i.e. "the slide show") to facilitate understanding of system concepts and to support high level program management presentations.</p> <p>The virtual prototype activities in this WBS element refer to the design, development, and iterative application of advanced computer simulations to facilitate early evaluation of new vehicle concepts prior to, during and after fabrication. Virtual prototyping includes computer solid models of alternative vehicle concepts and models that represent the performance of those concepts and their components to include the crew and support personnel. Incorporation of actual components in these models is included in virtual prototyping activities. System level simulation activities are tied to the virtual prototype task and include the development and application of Crusader performance and operational effectiveness models to support vehicle development efforts.</p> <p>The Distributed Interactive Simulation (DIS) activities in this WBS element refer to the design, development, fabrication and application of DIS-compatible crew stations for participating in distributed battlefield simulations and supporting concept expiration programs. It includes the development and application of DIS capabilities required to conduct system/organization simulations and experiments.</p>	



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<b>WBS Element:</b> 32000	<b>WBS Title:</b> System Program Management
The System Program Management element consists of those system development and program control activities, outside of technical design and development, that are needed to maintain direction, visibility and management control of the Crusader Program.	
<b>WBS Element:</b> 32100	<b>WBS Title:</b> System/Segment Development Program Management
<p>The Project Management element refers to the project planning necessary for organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall Crusader objectives. These include SPH, RSV, product assurance &amp; test, training system, production segment, and support activities which are not associated with system elements and are not included in system engineering (WBS 31000). Project management for areas other than those contained in this element and required as part of system development will be contained within each activity area.</p> <p>The system/segment development management activities in this WBS element refer to all efforts to manage system development activities. This includes staffing, organization, procedural training, development of directives and standards, process reviews, planning and conducting meetings, program communication methods and acquisition of specialized hardware or software for system development management purposes. This WBS element includes the program management of those technical efforts described within WBS element 31000 plus any other efforts at the system and segment level of the WBS. In each PDT level WBS element, a separate program management effort exists.</p> <p>The reviews activities in this WBS element refer to all activities to plan, organize, support and document all system development and system level reviews. This includes both formal reviews, such as SRR, PDR, SDR and CDR, and informal reviews. This element addresses only the system and segment development aspects of the scheduled reviews (e.g. if a specific review requires a focus on standard parts or system level testability the activity is absorbed within this elements and support for reviews below the segment development level is to be planned and budgeted within each individual PDT).</p> <p>The product assurance management activities in this WBS element refer to hardware and software quality assurance, and reliability, and maintainability (R/M) associated with analysis, design, fabrication, and test at the Crusader system and segment level. Included in this effort is implementation and execution of the hardware and software QA system in accordance with the Quality Program Plans, the R/M system in accordance with the R/M program plans and test activities in accordance with the Master Test Plan. Product assurance management activities below the system and segment level are carried out in support of each PDT and are identified in the respective WBS element.</p> <p>The program protection activities in this WBS element refer to personnel, equipment, data and procedures, and facilities modifications required to meet Crusader program security requirements relative to design, fabrication, procurement, and test operations. Effort involved includes security management, integration, documentation, guards, document control activities and advisory services.</p>	

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<b>WBS Element:</b> 32200	<b>WBS Title:</b> Program Control Project Management
<p>The Program Control Project Management element refers to the effort necessary for organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall Crusader program objectives. These include SPH, RSV, training system, and support activities which are not associated with system elements and not included in system engineering. The WBS element includes engineering, management, logistic, administrative, planning and control activities necessary to support effectiveness monitoring activities and processes during development and the program life cycle. Functions included in this element are GFP/GFE management, subcontract management, and planning and control.</p> <p>The subcontract management activities in this WBS element refer to the effort associated with maintaining and executing a management plan of system development subcontractor activities. Subcontract management activities below the system development level are delegated to the segment and PDT levels and those activities are supported in the product support WBS element for each PDT.</p> <p>The planning and control activities in this WBS element are those activities directly related to the cost/schedule control system (CS<sup>2</sup>) and its application to the Crusader program at the system development level. This includes overall Crusader project planning, budgeting, scheduling, performance analysis, and project cost/schedule reviews. Planning and control activities below the system/program and segment levels are carried in the product support function for each PDT.</p>	
<b>WBS Element:</b> 40000	<b>WBS Title:</b> Training
<p>The Training element refers to the deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction and to train operator and maintenance personnel to acquire sufficient concepts, skills and aptitudes to operate and maintain the Crusader system with maximum efficiency. This element includes all effort associated with the analysis, design, development and production of deliverable training equipment as well as the execution of training services. It also includes the effort required to integrate the elements of the training system with Crusader and to blend it into the government facilities and training infrastructure.</p>	
<b>WBS Element:</b> 41000	<b>WBS Title:</b> Training Equipment
<p>The Training Equipment element refers to those distinctive deliverable end items of training equipment, assigned by either a contractor or military service, required to meet system training objectives. This element includes appended and umbilical embedded training equipment, operational trainers and maintenance trainers. It excludes embedded training hardware on-board the SPH and RSV.</p>	
<b>WBS Element:</b> 42000	<b>WBS Title:</b> Training Services
<p>The Training Services element refers to the deliverable services, accessories, and aids necessary to accomplish the objectives of the system training. This element includes training course materials, contractor conducted training including in-plant and service training, and the materials and curriculum required to design, execute and produce a contractor developed training program. It also includes the material, courses, and associated documentation (primarily the computer software, courses and training aids). This element excludes the deliverable training data associated with the WBS element Support Data.</p>	

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<b>WBS Element:</b> 43000	<b>WBS Title:</b> Training Facilities
The Training Facilities element refers to the development of requirements and special construction necessary to accomplish training objectives. It also includes the requirements and modification or rehabilitation of existing facilities used to accomplish training objectives. The installed equipment used for the purpose of acquainting the trainee with the system or establishing trainee proficiency is excluded. The brick and mortar-type facilities identified as industrial facilities are also excluded.	
<b>WBS Element:</b> 50000	<b>WBS Title:</b> Data
The Data element refers to the collection, processing, accessing and distribution of all Crusader program information that has been assembled in a form suitable for review. This includes technical publications, support data, management data, engineering data, electronic access services, data management systems (both hardcopy and electronic).	
<b>WBS Element:</b> 51000	<b>WBS Title:</b> Technical Publications
The Technical Publications element refers to the technical data which provides instructions for the installation, operation, maintenance, training, and support of the Crusader system which is formatted into a technical manual (paper or magnetic media). A technical manual normally includes operation and maintenance instructions, parts lists or parts breakdown, and related technical information or procedures exclusive of administrative procedures. This data may be presented in any form (regardless of the form or method of recording). Technical orders that meet the criteria of this definition may also be classified as technical manuals. Data Management for this element refers to those tasks necessary to manage, integrate, convert, retain, archive, and assure security of all technical publications data, and associated data processes and workflows. This element includes, but is not limited to: (a) data requirements identification and definition (CDRLs, non-CDRLs, other data items), (b) marking of technical data adherence, (c) monitoring data preparation, (d) tracking data preparation, (e) delivery of data, (f) delivery format, (g) status tracking and reporting, (h) data to milestone coordination, (i) preparation and delivery methods, (j) recording/notification of deliverables, (k) receipts/acknowledgments tracking, (l) retention, archival, and retrieval procedures, and (m) data library procedures.	
<b>WBS Element:</b> 52000	<b>WBS Title:</b> Support Data
The Support Data element refers to those data items designed to document the Crusader support planning. This element includes, for example, LSA documentation and LSA record maintenance and delivery, supply, general maintenance plans and reports, training data, transportation, handling, packaging information, facilities data, data to support the provisioning process and all other support data, and software supportability planning and software support transition planning documents. Data Management for this element refers to those tasks necessary to manage, integrate, convert, retain, archive, and assure security of all support data, and associated data processes and workflows. This element includes, but is not limited to: (a) data requirements identification and definition (CDRLs, non-CDRLs, other data items), (b) marking of technical data adherence, (c) monitoring data preparation, (d) tracking data preparation, (e) delivery of data, (f) delivery format, (g) status tracking and reporting, (h) data to milestone coordination, (i) preparation and delivery methods, (j) recording/notification of deliverables, (k) receipts/acknowledgments tracking, (l) retention, archival, and retrieval procedures, and (m) data library procedures.	

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<b>WBS Element:</b> 53000	<b>WBS Title:</b> Contractor's Integrated Technical Information System (CITIS)
<b>WBS Element:</b> 53100	<b>WBS Title:</b> Contractor's Integrated Technical Information Service
<p>The CITIS element refers to a facility for establishing and maintaining a master information depository service for approved Crusader program data (both electronic, paper, and other media) that are the property of the U.S. Government as well as access to in-process data generated during the performance of this contract. This element includes equipment and all effort of design, development, operation and support required to provide the service. Delivery of Crusader technical/engineering data from the Contractor to the PM office will be in a machine readable form, or in hard copy on an exception basis with approval by the program office. In addition to providing engineering data delivery and management services to the PM office, the CITIS will serve as the mechanism by which the large, geographically dispersed industry team will share engineering data during the development of the weapons system during Dem/Val. As custodian for the government, the Contractor is authorized by approved change orders to maintain master program data at the latest approved revision level. When documentation is called for on a given item of data retained in the depository, the charges (if charged as direct) will be to the appropriate data element.</p>	
<b>WBS Element:</b> 53200	<b>WBS Title:</b> Common Development Environment
<p>The Common Development Environment element includes the costs and activities associated with establishing, implementing and maintaining a common product development toolset for this program. This element includes, but is not limited to: software, hardware, operations, maintenance, installation, customization, integration, testing, consulting, training, documentation, procurement, asset management, and on-going analysis efforts and support of engineering tools (systems, software, mechanical, logistics, others) that were identified within the common development environment plan established in the RA/CM period of performance. It excludes telecommunications, printer, plotter, and office automation equipment at Government, prime contractor, principal subcontractors, and any other subcontractor.</p>	
<b>WBS Element:</b> 53300	<b>WBS Title:</b> ADP Asset Management
<p>The CITIS Asset Management element refers to those tasks and systems necessary to manage the procurement and use of material items, hardware and software licenses, maintenance agreements, in support of the CITIS and the Common Development Environment. This element performs asset management at all Crusader Teammate sites, including prime contractor, principal and other subcontractors, and selected Government sites, as needed. It excludes asset management of printer, plotter, and office automation equipment at Government, prime contractor, principal subcontractors, and any other subcontractor. Overall asset management will be performed by the prime contractor.</p>	



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<b>WBS Element:</b> 53400	<b>WBS Title:</b> Data Management
<p>Data Management refers to those tasks necessary to manage, integrate, convert, retain, archive, and assure security of all data, and associated data processes and workflows. This includes, but is not limited to: (a) data requirements identification and definition (CDRLs, non-CDRLs, other data items), (b) marking of technical data adherence, (c) monitoring data preparation, (d) tracking data preparation, (e) delivery of data, (f) delivery format, (g) status tracking and reporting, (h) data to milestone coordination, (i) preparation and delivery methods, (j) recording/notification of deliverables, (k) receipts/acknowledgments tracking, (l) retention, archival, and retrieval procedures, and (m) data library procedures. This element includes technical publications, support data, management data, engineering data, providing requirements for electronic access services, and responsibility for data management systems (both hardcopy and electronic).</p>	
<b>WBS Element:</b> 54000	<b>WBS Title:</b> Management Data
<p>The Management Data element refers to those data items necessary for configuration management, cost, schedule, contractual data management, program management, etc., required by the government for the Crusader system. This element includes contractor cost reports, cost performance reports, contractor fund status reports, schedules, milestones, networks, integrated support plans, etc. Data Management for this element refers to those tasks necessary to manage, integrate, convert, retain, archive, and assure security of all management data, and associated data processes and workflows. This element includes, but is not limited to, (a) data requirements identification and definition (CDRLs, non-CDRLs, other data items), (b) marking of technical data adherence, (c) monitoring data preparation, (d) tracking data preparation, (e) delivery of data, (f) delivery format, (g) status tracking and reporting, (h) data to milestone coordination, (I) preparation and delivery methods, (j) recording/notification of deliverables, (k) receipts/acknowledgments tracking, (l) retention, archival, and retrieval procedures, and (m) data library procedures.</p>	
<b>WBS Element:</b> 55000	<b>WBS Title:</b> Engineering Data
<p>The Engineering Data element refers to the recorded information (regardless of the form, media, or method of recording) of a scientific nature (including computer software documentation). Engineering data is required to define and document an engineering design or product configuration (sufficient to allow duplication of the original items) and is used to support Crusader activities in production, engineering, and logistics. This element includes, for example, all final plans, procedures, reports, and documentation pertaining to the Crusader system, its subsystems, computer and computer resource programs, component engineering, operational testing, test and evaluation, human factors, reliability, availability, and maintainability, and other engineering analysis. A technical data package includes all engineering drawings, associated lists, process descriptions, and other documents which define the physical geometry, material composition, and performance procedures. Data Management for this element refers to those tasks necessary to manage, integrate, convert, retain, archive, and assure security of all engineering data, and associated data processes and workflows. This element includes, but is not limited to, (a) data requirements identification and definition (CDRLs, non-CDRLs, other data items), (b) marking of technical data adherence, (c) monitoring data preparation, (d) tracking data preparation, (e) delivery of data, (f) delivery format, (g) status tracking and reporting, (h) data to milestone coordination, (I) preparation and delivery methods, (j) recording/notification of deliverables, (k) receipts/acknowledgments tracking, (l) retention, archival, and retrieval procedures, and (m) data library procedures. This element excludes tasks performed under Configuration Management Control, such as configuration identification and establishment of baselines, change control, as-built lists, and determination of CM audits and CM reviews.</p>	

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

<b>WBS Element:</b> 60000	<b>WBS Title:</b> Peculiar Support Equipment (PSE)
<p>The PSE element refers to the total complement of equipment, services, facilities and includes the program integration of the complete peculiar support system. The peculiar support equipment element refers to the design, development, and production of those deliverable items and associated software required to solely support and maintain the SPH and RSV or portions of the system while not directly engaged in the performance of its mission, and which have application peculiar to a given defense material item. This element includes, for example, vehicles, equipment, tools, etc., used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain the systems equipment. It also includes any production of duplicate or modified factory test or tooling equipment delivered to the government for use in maintaining the SPH and RSV (factory test and tooling equipment initially used by the contractor in the production process but subsequently delivered to the government will be included as cost of the item produced). It also includes any additional equipment or software that will be required to maintain or modify the software portions of the system. This element excludes the common support equipment presently in the DoD inventory or commercially common within the industry which is bought by the using command and not the acquiring command.</p>	
<b>WBS Element:</b> 61000	<b>WBS Title:</b> Test and Measurement PSE
<p>The test and measurement element refers to the peculiar or unique testing and measurement equipment which allows the operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational, intermediate, or depot level of equipment support. It includes test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, tap(s), and related software, firmware and support hardware (power supply equipment, etc.) used at all levels of maintenance. It includes packages which enable a line or shop replacement unit, printed circuit boards, or similar items to be diagnosed using automatic test equipment.</p>	
<b>WBS Element:</b> 62000	<b>WBS Title:</b> Support and Handling PSE
<p>The support and handling PSE element refers to the deliverable tools and handling equipment. It typically includes ground support equipment, vehicular support equipment, powered support equipment, nonpowered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware/software).</p>	
<b>WBS Element:</b> 70000	<b>WBS Title:</b> Common Support Equipment (CSE)
<p>The CSE element refers to the total complement of equipment, services, facilities and includes the program integration of the complete support system. The CSE element refers to those items required to support and maintain the SPH and RSV or portions of the system while not directly engaged in the performance of its mission, and which are presently in the DoD inventory for support of other systems. This element includes all efforts required to assure the availability of this equipment for support of the particular defense materiel item. It also includes the acquisition of additional quantities of this equipment if caused by the introduction of the defense materiel item into operational service.</p>	

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<b>WBS Element:</b> 71000	<b>WBS Title:</b> Test and Measurement CSE
The test and measurement CSE element refers to the common testing and measurement equipment which allows the operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational, intermediate, or depot level of equipment support. It includes test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, tap(s), and related software, firmware and support hardware (power supply equipment, etc.) used at all levels of maintenance. It includes packages which enable a line or shop replacement unit, printed circuit boards, or similar items to be diagnosed using automatic test equipment.	
<b>WBS Element:</b> 72000	<b>WBS Title:</b> Support and Handling CSE
The support and handling CSE element refers to the deliverable tools and handling equipment used for support of the SPH and RSV. It typically includes ground support equipment, vehicular support equipment, powered support equipment, nonpowered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware/software).	
<b>WBS Element:</b> 80000	<b>WBS Title:</b> Operational/Site Activation
The Operational/Site Activation element refers to the total complement of real estate, construction, conversion, utilities, and equipment required to house, service, and launch the SPH and RSV mission equipment at organizational, intermediate and depot sites. Normally provided by the contractor, it includes efforts to assemble, checkout and install equipment, including minor modifications to integrate the equipment and facility systems. It excludes resources applied to the Military Construction Program (MCP).	
<b>WBS Element:</b> 90000	<b>WBS Title:</b> Industrial Facilities
The Industrial Facilities element refers to the total construction, conversion, or expansion of industrial facilities for production, inventory, and depot maintenance required for both the SPH and RSV systems. This element includes, for example, equipment acquisition or modernization, where applicable, and maintenance of these facilities or equipment. This element also includes industrial facilities for hazardous material management to satisfy environmental standards.	
<b>WBS Element:</b> 91000	<b>WBS Title:</b> Construction, Conversion, and Expansion
The construction, conversion, and expansion element refers to the real estate and preparation of industrial facilities for production, inventory, depot maintenance, and other related activities. This element also includes industrial facilities for hazardous material management to satisfy environmental standards.	
<b>WBS Element:</b> 92000	<b>WBS Title:</b> Equipment Acquisition or Modernization
The equipment acquisition or expansion element refers to production equipment acquisition, modernization, or transferal of equipment. (Pertains to government owned and leased equipment under facilities contract.)	
<b>WBS Element:</b> 93000	<b>WBS Title:</b> Maintenance (Industrial Facilities)
The maintenance (industrial facilities) element refers to the maintenance, preservation, and repair of industrial facilities and equipment. This element also includes the maintenance of industrial facilities for hazardous material management to satisfy environmental standards.	

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<b>WBS Element:</b> A0000	<b>WBS Title:</b> Initial Spares And Repair Parts (IS&RP)
<p>The IS&amp;RP element refers to the total complement of components and equipment necessary to sustain the SPH and RSV during initial fielding. This element includes the repairable spares and repair parts required as initial stockage to support and maintain newly fielded systems or subsystems during the initial phase of service, including pipeline and war reserve quantities, at all levels of maintenance and support. This element excludes development test spares and spares provided specifically for use during installation, assembly and checkout on site. The lower level WBS breakouts should be by subsystem.</p>	

### C. Lessons Learned

#### LESSONS LEARNED - WBS

- The IGCE kept trying to hit a moving target as WBS changes rippled through the program. Examples follow:
  - MIL-STD 881B, WBS Structure for Defense Material Items is the traditional standard. Early in the development of the RFP, DoD's adherence to the untailored WBS specified was determined.
  - As the contractor team addressed the Performance Spec/IPT approach several major changes/departures resulted. Each change drove IGCE revamps.
  - At DoD direction in May/June 1995, this emerging contractor WBS was reoriented to conform to the MIL-STD. The effect on the IGCE was to cause dispersion of costs, or merging of costs, into new WBS categories with less than desirable logic trails as to rationale. The estimate is considered valid, but the need for an extensive roadmap to follow the rationale and audit trail from old to new WBS caused the IGCE resultant to be more cumbersome than is desirable.
- At this juncture in Acquisition Reform/Streamlining, depart from traditional MIL-STD 881B at one's own peril!
- Avoid overlays; use dictionary to be specific.
- WBS is a key tool to manage and control work.
- WBS is the basis for cost estimate and IGCE.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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## **CHAPTER III**

### **RA/CM AND LESSONS LEARNED**

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**25. REQUIREMENTS ANALYSIS AND COMPONENTS MATURATION (RACM)**

**A. Contractor's RACM**

*i. PCO Receipt of Contractor (Team AFAS) RACM*

Task 1 of the SOW in DAAA21-94-R-0054 required the contractor to conduct a requirements analysis of the AFAS/FARV ORD and the draft AFAS/FARV system specifications. The PCO received the contractor's RACM on 4 November 1994 and secured the document until the IGCE Team completed its RACM estimates and provided it to the PCO who would use both documents prior to negotiations with the contractor for the RACM phase of the AFAS/ FARV project.

*ii. Team AFAS - System Development Objectives*

<b>AFAS/FARV SYSTEM DEVELOPMENT OBJECTIVES</b>
<ul style="list-style-type: none"><li>• Analyze AFAS/FARV system requirements - defines requirements for objective system and Phase I/II prototypes.</li><li>• Develop system concept - includes key technologies that enable full system development.</li><li>• Identify critical technical, schedule, and cost risks associated with system design.</li><li>• Develop and implement critical risk mitigation/management plans to mitigate high risks.</li><li>• Develop and test system prototypes - validates system concept to prepare system to enter Phase III.</li><li>• Develop Phase III system specification for full system development.</li></ul>



The contractor (Team AFAS) identified a number of critical risks associated with objectives three and four that require early attention to ensure that technologies and components are sufficiently matured for Phase I/II completion. These components and technologies were identified in Team AFAS's component maturation master plan and project implementation plans. In addition to these component maturation plans, the requirements analysis effort was to begin immediately to ensure overall Phase I/II schedule compliance. All RACM activities outlined were an integral part of the Team AFAS Phase I Development plan which is to be described in detail in the Task 3, Phase I/II Development Plan proposal.

Prior to Dem/Val Phase I contract award, the contractor was to complete requirements analysis through system requirements review. Following the review, the initial system/segment specification, top-level physical architectures, and supporting data will be available to the PDTs, ensuring a smooth transition into Dem/Val Phase I. By Phase I, PDTs are established and functioning.

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### iii. Team AFAS - RACM Objectives

#### SPECIFIC OBJECTIVES OF RACM

- Review, analyze, and assess the AFAS/FARV operational requirements document (ORD) and specification requirements.
- Initiate trade study-supported concept baselines for the objective AFAS/FARV system and the DEM/VAL Phase II prototypes.
- Develop a modeling and simulation plan for Dem/Val Phase I/II.
- Plan a risk management project for RACM and Dem/Val for Phase I implementation. Identify and assess high-risk project elements early (e.g., liquid propellant cannon development). Develop risk mitigation strategies (e.g., early demonstration and testing in Dem/Val).
- Plan and manage the execution of component maturation focused on early maturation of high-risk components to provide performance data for modeling and simulation.
- Analyze, design, develop, integrate, and prototype the CITIS so it is incrementally available shortly after Dem/Val award.
- Establish and implement the IPD process to minimize Project execution risk for Phase I/II.

Team AFAS will use a requirements and technology maturation process to successfully drive system design and validation. An in-process review will be presented to the PEO in mid-February as part of the Requirements Analysis (RA) task. Results of the In-Process Review (IPR) will allow preliminary allocation of the requirements to develop Phase II AFAS/FARV prototype concepts and define the initial objective system elements. Reviews are scheduled as a mechanism to further allocate requirements at the segment and element levels.

### B. Lessons Learned

#### LESSONS LEARNED - UDLP RACM

- A contract definition effort was necessary to keep the contractor's core team together and as a mechanism to deliver government assistance to the contractor teams in executing a proposal of vastly different content. The defense contractor team had to prepare the SOW, not just respond with technical approach and costs.
- The purpose of RA/CM is risk reduction, a worthy cause on risky RLPG, Propulsion, and Automated Ammunition Handling.
- CITIS is key to the start, too. A system must be in place before the content information is available.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**26. IGCE RACM**

**A. IGCE RACM Approach**

The IGCE RACM was based on the 4 November 1994 Preliminary Draft version of the RACM WBS, SOW, and IMP. Additionally, draft documentation describing planned component maturation projects and the requirements analysis process were compared to similar AFAS/FARV work package efforts to balance the IGCE's assessment of the RACM effort. The focus and size of the IGCE development effort centered on providing a clear and reasonable cost baseline to compare the UDLP RACM proposal when delivered. For the purpose of the IGCE, any implied workshare between UDLP and its subcontractors was based solely on information in the preliminary draft or IGCE Team assumptions which were described in the IGCE worksheets.

**B. Detailed Factors and Rationale**

Engineering Labor rate was based on UDLP Team AFAS Contract Definition Proposal dated 5 August 1994. Overhead rate was also based on the Contract Definition proposal. G&A and Profit are based on FY94 Average contractor rates provided by SAIC's Program Acquisition and Cost Technologies Division. There was an additional charge by UDLP for work activities performed by other contractors under the Contract Definition proposal.

**C. November Meeting**

A final RACM meeting was held by Kevin Holmes and Mort Anvari with all members of the IGCE Team. The purpose was to ensure that all cost estimates were completed and that everyone was in a general consensus prior to delivering the final cost estimate on 10 November to the Advanced Systems and Concepts Office (ASCO) for validation.

**D. IGCE - RACM Validation**

The IGCE requirements analysis and component maturation estimates were validated by the Advanced Systems Concepts Office (ASCO) on 11 November 1994. Also, on the same day, all IGCE Team members were brought together and briefed on the results of the RACM by Mort Anvari.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**E. Lessons Learned**

LESSONS LEARNED - IGCE RACM
<ul style="list-style-type: none"><li>• A small team was sufficient to do RACM.</li><li>• The same methods and tools used later for IGCE and Requirements Analysis Component Maturation Extension (RACMe) - great practice run for larger IGCE.</li><li>• RACM had to be done quickly and accurately. A small senior team was the best approach.</li><li>• RACM was used to confirm process, tools, and procedures.</li></ul>

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## **CHAPTER IV**

### **IGCE DEVELOPMENT AND LESSONS LEARNED**

**Additional Lessons Learned, Updating, and Notes for Crusader**

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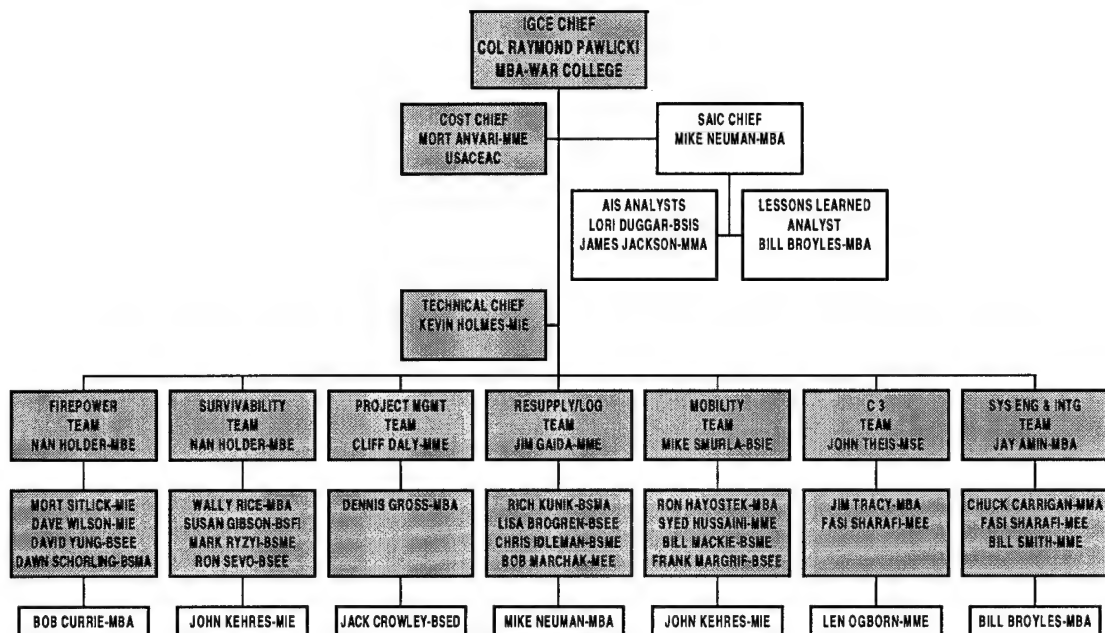
**NOTES**

## 27. INDEPENDENT GOVERNMENT COST ESTIMATE (IGCE) TEAM

### A. Background

The AFAS/FARV IGCE Team project was approved effective 9 September 1994 and the support contractor [Science Applications International Corporation (SAIC)] SOW and contract were effective 30 September 1994.

### B. Team Organization.



ARMY	SAIC
------	------

MBA	MA BUS ADMIN	MME	MA MECH ENGR
MIE	MA INDUST ENGR	MBE	MA BIO ENGR
MEE	MA ELEC ENGR	MMA	MA MATH
BSMA	BACH MATH	BSED	BACH EDUC
BSEE	BACH ELEC ENGR	BSIE	BACH INDUS ENGR
BSFI	BACH FINANCE	BSME	BACH MECH ENGR

### C. IGCE Strategy.

A Statement of Work (SOW) was prepared by the office of the PM, and using a task order contract through the US Army Cost and Economic Analysis Center, a contract was issued

**Additional Lessons Learned, Updating, and Notes for Crusader**

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to Science Applications International Corporation (SAIC) effective 30 September 1994. The purpose was for IGCE support to the AFAS/FARV project. The four tasks in this contract were:

- **TASK 1** - Assist the AFAS/FARV Project Management Office in Preparation of an IGCE for the Dev/Val Phases 1 & 2 Contract. The effort included: a review of the RFP; review of scope of work with Government and contractor personnel; assist in the preparation of the IGCE; Assist the Government in finalizing the SOW to an affordable cost; facilitate interactions and coordination among all involved with the IGCE; make available all knowledge of risk, costs, Cost Estimating Relationships (CERs), models, methodology and data bases; develop and maintain an integrated master schedule; perform an independent risk analysis; maintain and support the defense of the IGCE; and a final IGCE report.
- **TASK 2** - Develop Army Cost Estimating Integrated Tools (ACEIT) Automated Reports. Details of this effort are in Section 39, page IV-45.
- **TASK 3** - Provide Acquisition, Technical, Cost, Schedule and Risk Analysis Support to the AFAS/FARV Follow-on Team. This effort is to provide the requisite analysis support during the RFP and technical evaluation phases. SAIC is to provide evaluations of technical and cost alternatives and tradeoffs in the support of the follow-on IGCE team.
- **TASK 4** - Document the AFAS/FARV Program Management Office's (PMO's) IGCE Process and Results. Review historical documentation; Provide background for the Army's streamlining/acquisition approach; Interview key players - IGCE Team Chiefs/personnel, IPT members, Senior contracting personnel, key Army and OSD officials; Develop an acquisition "Roadmap" for Army and DoD; Document a "Lessons Learned" from the AFAS/FARV project; and Provide a report and briefing for Senior Army and DoD officials.

### **D. Team Building.**

Teams can be powerful entities, but require individual members to function differently than each normally would in their original work environment. The training for team building was targeted towards obtaining personal insight, team progress, and a successful project planning experience. All personnel met in the large conference room of the Army's Corps of Engineers in building 3022.

#### *i. 24 October 1994.*

COL Raymond Pawlicki, on loan from ARDEC and selected as the IGCE Team Chief, gave the opening introduction and a very warm welcome. He explained why everyone was there and that he was representing the Honorable Gilbert R. Decker, the Assistant Secretary of the Army for Research, Development and Acquisition. COL Pawlicki explained the importance of



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

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the AFAS/FARV IGCE and that Mr. Decker must approve it prior to the PCO making an offer to the contractor and that it was the basis for the contract negotiations. He also stated that everyone must work concurrently with the contractors in development of the WBS, but warned that members were not to ask for or accept contractor cost estimates unless they were historical costs. COL Pawlicki then established his IGCE rules which were:

- Okay to receive data from contractor
- Will be one to two visits to contractor
- No cost or hour data exchange
- PCO, Defense Contract Audit Agency (DCAA) and Defense Plant Representative Office (DPRO) representatives are available to assist
- Most work to be performed at Picatinny
- Maintain independence from the Government SOW advisory team
- All clarifications must go through the PCO

COL William B. Sheaves III, the Project Manager for AFAS/FARV, followed with a detailed briefing titled "Senior Level Integrated Product Team Coordinating Council (SLICC)." COL Sheaves had briefed the Army Systems Acquisition Review Council (ASARC) the previous week and many of the charts were from that briefing which was a prelude for a AFAS/FARV briefing scheduled for an OSD DAB on 15 November 1994. COL Sheaves presented some background on the AFAS/FARV project and what changes have occurred to that project. The following was covered in his briefing:

- AFAS/FARV Streamlining
- AFAS/FARV Initiatives
- OSD Review Initiatives
- Summary.

Mr. Jeffrey M. Boyle, The Procurement Contracting Officer (PCO) ensued with the pros and cons of the IGCE team members during their production of cost estimates and their relationship with the IPTs and the contractor. He also discussed the Requirements Analysis/Component Maturation and the propulsion download. He recommended that members get involved with DCAA early.

In the afternoon of 25 October 1994, Mr. Kevin Holmes, the Technical Chief, presented his briefing on how the technical teams and their functions should operate. The following was emphasized:

- Develop a Team Agenda
- Coordinate Team Work Schedule
- Brief Back Early and Often
- Address Disconnects/Reset Problem Areas
- Balance Knowledge Base
- Promote Free Flow of Ideas

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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Mr. Mort Anvari, the Cost Chief from the US Army Cost and Economic Analysis Center gave a detailed briefing on how the Army Cost Center operated under the direction of the Assistant Secretary of the Army Force Modernization [ASA(FM)] and also how the Army's Cost Review Board functioned.

He was followed by Mr. Michael Niggel, SAIC Vice President, who explained how SAIC personnel assigned to the IGCE would function and provide support. The three briefings, to include questions and answers, were about an hour each.

Two days of Team Building training was contracted out to John C. Crowley, Jr., an experienced TQM Consultant and TQM Auditor certified by the state of New Jersey.

*ii. 25 October 1994.*

**Day 1** - (0800-1200) Each IGCE member was given a workbook for the two-day team building. Introductions were made by all followed by Mr. Crowley's administrative items, agenda, and workbook instructions.

All participants were administered the Myers-Briggs Type Indicator (MBTI) Test Tool, an instrument that enables people to communicate and work together more effectively through understanding individual preferences. The MBTI is used in business and education for career counseling, team building, conflict resolution, and management development. After the overview, members were tested, and scored and learned how the MBTI related to their teams.

Members were then placed within their respective teams (see page IV-1 for the team organizations) and received instruction on techniques for success. At the end of day 1 training, each member was given "homework" for day 2.

*iii. 26 October 1994.*

**Day 2** - (0800-1600) The first hour was spent reviewing the homework which consisted of questions concerning what each member felt had to be accomplished within their respective team (e.g., name and mission of the team, the team's life-cycle and unprioritized listing of major tasks/milestones, a prioritized listing of the major tasks, a listing of subtasks, and a skills inventory).

COL Pawlicki then presented his vision for the AFAS/FARV IGCE Team, to:

**"Create a team environment which encourages innovation and efficiency and results in the establishment of a Department of the Army standard for this and future weapon systems cost estimates as demonstrated by achieving AAE approval of our report."**

**Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

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He emphasized that this is the largest and best IGCE ever gathered in the Army and that the cost and technical members are a fully integrated team. He also stressed the importance of communications. All members participated in drafting this vision and also discussed team missions, values, goals, objectives, and metrics, applying their previous night's "homework." The remainder of the morning was spent exchanging team skills inventory, brainstorming team charter statement (mission), goals, and objectives statement. Each team assessed their progress by scoring their prior session in the format presented in Section 28, Crusader IGCE Team Survey, noting progress from prior sessions. Team charters, goals, and objectives were prepared for later presentation.

After lunch, the teams drafted GANTT charts, and subtasks and prepared for end of the day out-briefs to COL Pawlicki. This included:

- Team Mission, Vision, Values
- Goals, Objectives, Metrics
- Team Coordination, Communication, Follow-up Plan
- Overview GANTTs
- Detail GANTTs
- Resources Needed/Challenges
- Summary - Red, Green, Yellow and Why

The teams out-briefed COL Pawlicki and their colleagues, with discussion (and minimal fine-tuning), on schedule. Their work plans were accepted, and the teammates completed their IGCE work. Mr. Crowley, invited to participate in the IGCE process, developed a "War Room" for the teams to record their status and, to capture and share progress. Near the conclusion of the IGCE effort, Mr. Crowley conducted a survey of participants, the results of which appear in Section 28.

### E. Lessons Learned.

#### LESSONS LEARNED - IGCE TEAM

- OPM Crusader invested significant resources in executing this mandated IGCE effort. Payback results will be known based upon the end of a smoothly negotiated, fully comprehensible, fair and reasonable contract award for Dem/Val.
- The Team-building process served well to "jump start" teams, who gained some sensitivity to team dynamics, but were rapidly driven to develop their conceptual basis (Mission, Vision, Values), then develop an initial plan/commitment. This process delivered rapid results, sidestepping the traditional agonies of "storming," in the usual "forming, norming, storming, and performing" profile of most teams. Further lessons learned near the conclusion of the IGCE process was provided in Section 28, reflecting the views of the IGCE participants.
- There is substantial value in employing a contractor with IGCE, Army and Tracked and Wheeled Vehicle (T&WV) experience, tools and databases to support an IGCE process.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## **28. CRUSADER IGCE TEAM SURVEY**

### **A. Introduction**

Building upon the Team Building initiatives discussed in Section 27, a survey tool was devised by Messrs. Broyles and Crowley and distributed to all local and remote Government and contractor teammates. The survey tool, in compressed form, is provided below, along with COL. Pawlicki's remarks regarding the utility of the information to be derived.

### **B. Key Survey Elements.**

Designed both to derive team members' assessment of the team work processes during the IGCE experience, and to gather follow-on information for tracking and updating of the IGCE result during the Summer, the survey tool requested that participants respond in some detail, to the survey, reconstituted in compressed fashion, below. Key information elements of the survey included the following:

- Feedback on teaming and communications
- Recommendations for improvement of the IGCE process and contractor support
- Confidence levels by WBS element and rationale for low-confidence elements or uncertainty
- A watchlist, by affected WBS, along with points of contact, for tracking and updates
- Lessons learned input/recommendations for future streamlined acquisition IGCE teams
- A 360 degree appraisal of "Superstar Performers" within the IGCE teams and outside organizations.

### **C. Team Response.**

By COB on 14 March 21 surveys had been returned to the sponsors, reflecting a 57% response rate.

The survey tool is provided below, compressed for readability:



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

### Crusader IGCE Team Survey

2/28/95

Before the Independent Government Cost Estimate (IGCE) phase of our work winds down and all of us move on, I'd appreciate your help in thinking about the IGCE process - what we learned, and how we and others can use this information in the future. The following survey seeks your assessments, ideas and recommendations. If you need more space, add sheets as necessary. I'd appreciate the return of your questionnaires to Bill Broyles by 1000 Friday, 10 March. Team leaders are requested to fax copies of the survey to teammates who are not local this week.

Thank you for the great job you've all done so far, and your patience and best efforts as we put the finishing touches on labor categories, final estimates and "what ifs"!

Raymond Pawlicki  
Colonel, U.S. Army  
Chief, Crusader IGCE Team

#### IGCE TEAM PROCESS ASSESSMENT

Circle the number which best reflects your perception of the group process FOR THE IGCE TEAM as a whole:

##### FOCUS

1	2	3	4	5	6	7	8	9
No planning evident; plan not followed				Plan followed - Team kept goals in sight				

##### PARTICIPATION

1	2	3	4	5	6	7	8	9
Few dominated; some held back				All contributed & were involved in decisions				

##### LISTENING

1	2	3	4	5	6	7	8	9
Crosstalk, interruptions & side conversations normal				One person at a time; ideas expanded & clarified				

##### LEADERSHIP

1	2	3	4	5	6	7	8	9
Leader let team stray; didn't encourage equal participation				Leader kept team on track; sought equal participation				

##### DECISION QUALITY

1	2	3	4	5	6	7	8	9
Team decisions were inferior to individual assessments				Team expertise and decisions were superior to individual judgments				

#### TEAM PROCESS ASSESSMENT

Circle the number which best reflects your perception of the group process FOR YOUR TEAM:

##### FOCUS

1	2	3	4	5	6	7	8	9
No planning evident; plan not followed				Plan followed - Team kept goals in sight				

##### PARTICIPATION

1	2	3	4	5	6	7	8	9
Few dominated; some held back				All contributed & were involved in decisions				

##### LISTENING

1	2	3	4	5	6	7	8	9
Crosstalk, interruptions & side conversations normal				One person at a time; ideas expanded & clarified				

##### LEADERSHIP

1	2	3	4	5	6	7	8	9
Leader let team stray; didn't encourage equal participation				Leader kept team on track; sought equal participation				

##### DECISION QUALITY

1	2	3	4	5	6	7	8	9
Team decisions were inferior to individual assessments				Team expertise and decisions were superior to individual judgments				

**Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

1. Our individual cost estimating team pulled together a. rarely, b. sometimes, c. usually, d. always

2. What were the major obstacles you and your team encountered. Please list and prioritize below:

- a. \_\_\_\_\_ overcome by \_\_\_\_\_  
b. \_\_\_\_\_ overcome by \_\_\_\_\_  
c. \_\_\_\_\_ overcome by \_\_\_\_\_

3. List the WBS' below that YOU WORKED CLOSELY ON. Please indicate your confidence factor about your result (from a low of 1 to a high of 5) below:

WBS #	CONFIDENCE #	WBS #	CONFIDENCE #

4. Refer to your responses to #3 above, please. For any WBS for a 1 or 2 rating, indicate reasons for your uncertainty, e.g., immature technology, little historical data, design uncertainty, unclear WBS definition or SOW, etc.

WBS #	REASONS FOR UNCERTAINTY

5. Along a scale from 1 to 5, how would you rate the effectiveness of the IGCE CCB in assisting teams problem-solve, stay focused and on track:

1      2      3      4      5

6. What assistance/strengths did the CCB bring to the project? How could the CCB have been more effective?

7. Would you single out a person or persons on your team for special praise? Who, and why.

8. Did any person or persons outside our IGCE group provide valuable assistance? Who, from what organization, and what assistance?

9. Please rate support contractor performance in the IGCE process?

1      2      3      4      5

How could better support be delivered in future IGCE-type programs?

10. What "Lessons Learned" from this project should be noted in our final report?

11. As the cost model transitions to ASCO, what are the pending developments, ambiguities, decisions or key events that we should include on our "Watch List" that could be a cost or schedule driver. Please list these items in enough detail so we can assess the area/WBS' affected and have your suggested points of contact.

WATCHLIST ITEM OR EVENT	WBS' IMPACTED	POTENTIAL AREA IMPACT	POINTS OF CONTACT

12. Please rate the quality of your IGCE participation experience in the following areas:

- a. Professional growth:      1   2   3   4   5;    areas:  
b. Learn new skills:            1   2   3   4   5;    specifically:  
c. Work with "sharp" people:   1   2   3   4   5;    examples:

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

#### D. Results and Analysis by Category.

IGCE Team feedback to be derived from the survey, as foreshadowed in subparagraph A above, included Teaming and Communications, Process Improvement, Confidence Levels by WBS, Watchlist Recommendations, Lessons Learned, and peer identification of any "Superstars" for the benefit of IGCE leadership. Each of these areas excepting "Superstar" nominations is discussed in turn below.

##### i. Teaming and Communications.

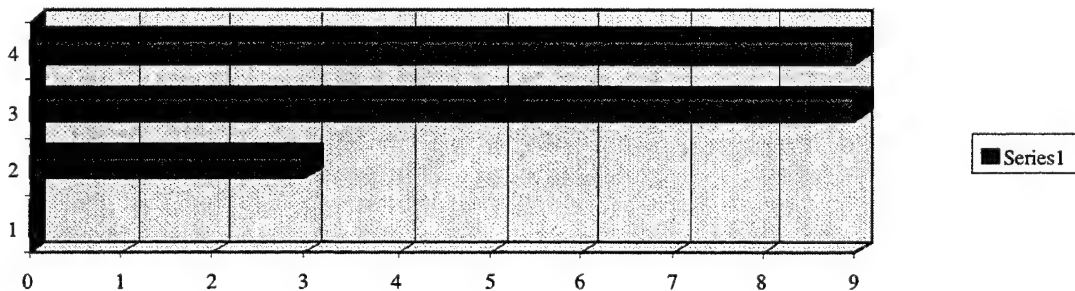
The initial survey page asked team members to assess/score both the overall IGCE Team and their (own) team in five areas: Focus, Participation, Listening, Leadership, and Decision Quality. As is usually experienced, own team scoring was usually higher than that assigned the larger (IGCE) entity.

##### ii. Additional Survey Questions.

Additional survey questions were constructed to derive team communications effectiveness information. Those questions and responses are as follows:

Our individual cost estimating team pulled together: a. rarely, b. sometimes, c. usually, d. always

Overall rating (a=1, b=2, c=3, d=4):



##### iii. Process Improvement

In addition to the Team Process Assessments presented in subparagraph 1 above, the following survey questions and responses relate to assessing and improving IGCE management processes:

##### Configuration Control Board (CCB) process.

Along a scale from 1 to 5, how would you rate the effectiveness of the IGCE CCB in assisting teams problem-solve, stay focused and on track: 1 2 3 4 5

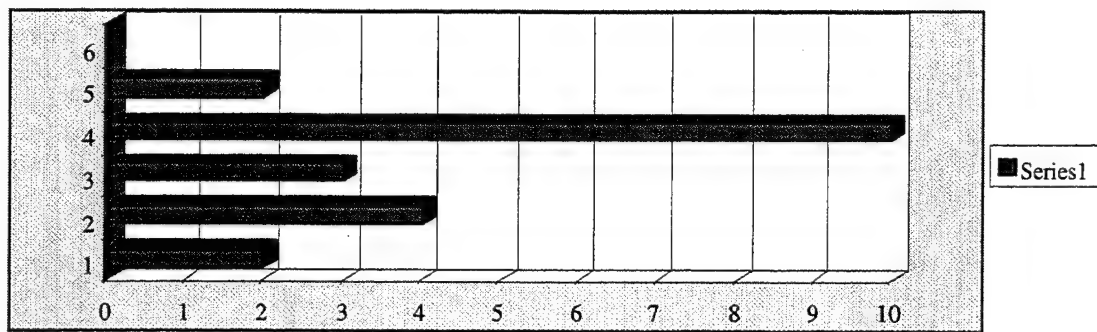
**Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader



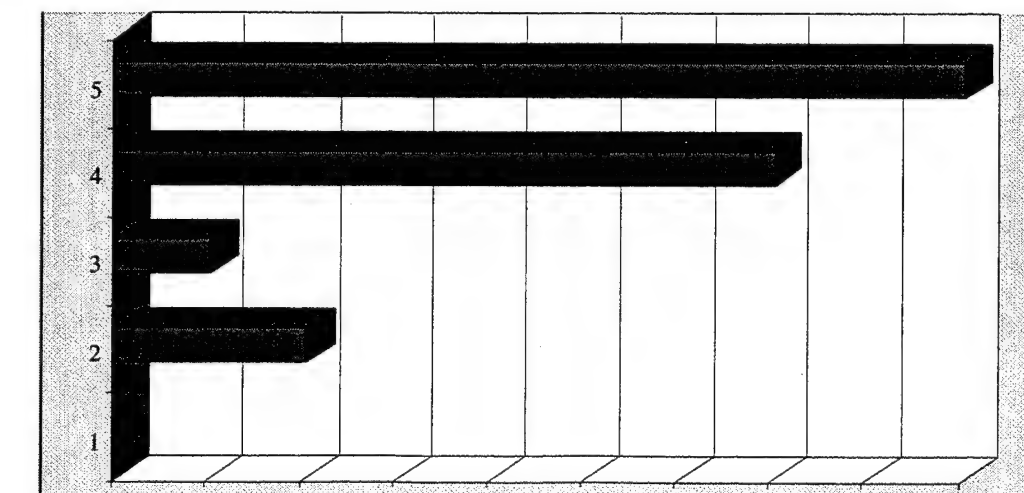
What assistance/strengths did the CCB bring to the project? How could the CCB have been more effective?

Areas of Strength/Assistance	Area for Future Improvement
Brought Teams together; helped focus (4 votes)	Needed earlier decisions on level of detail (4)
CCB had good ideas/recommendations (2)	Needed earlier direction on global issues, e.g., model, hours/manyears), (5)
CCB process was great/very good (2)	
CCB was committed (1), worked hard (1), was usually constructive (1), was good mix of tech/cost people (2)	IGCE members needed to assist/work more closely with the teams, not just review work (3)
None-CCB gave destructive criticism, no help or solutions. Belittled team members unfairly (1)	Could have gotten better communications between teams by conducting reviews (standup-type) which included all teams (3)
CCB had a hard job. (1)	Needed better communications with the Prime (1)

### iv. Contractor Support Evaluation.

Recommendations for improving contractor support processes in future IGCE/Cost Analysis projects was as follows:

Please rate the support contractors performance during the IGCE process? 1 2 3 4 5





## **Additional Lessons Learned, Updating, and Notes for Crusader**

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

### How could better support be delivered in future IGCE-type programs?

• Arrive with the model more firm (3)	• Allow for more Govt. input to model (2)
• More historical data needed (1)	• Needed more assistance (2)
• Needed more info on SAIC resources & how they could help us (2)	• Could take better care to match tech support to tech requirement (1) Needed more help with the estimates (1)
• Len Ogborn's work raised my grade to a 4! (1)	

### v. *Confidence Levels by WBS.*

Respondents were requested to report their confidence levels by WBS, then provide reasoning and rationale for those WBSs rated 1 or 2 on a 5-point scale. The question and averaged responses by WBS are provided as follows:

List the WBS' below that YOU WORKED CLOSELY ON. Please indicate your confidence factor about your result (from a low of 1 to a high of 5) below:

Self Propelled Howitzer(SPH) Resupply Vehicle (RSV)			Confidence 1=low;5=high
11000	System Development		3.1
	11100	System Engineering	3.4
	11200	Integration	3.4
	11300	MANPRINT	3.75
	11400	System Modeling and Simulation	2.75
	11500	System Development Project Management	2.12
	11600	Test and Checkout	3.25
12000	Armament		2.58
	12100	RLPG Primary Armament (PA) Cannon	1.7
	12200	RLPG PA Gun Mount	2.5
	12300	Projectile Loader Subsystem	2.87
	12400	Fluid Handling Assembly	2.87
	12500	Gun Pointing Subsystem	3.13
	12600	Turret Structure Subsystem	2.87
	12700	RLPG PA Peripherals	2.5
	12800	Position & Aiming Subsystem	2.6
	12900	RLPG PA Control Subsystem	2.37
	12A00	PA Product Support	2.6
	12B00	PA Product Development	2.37
13000	SPH Defensive Armament(s) (DA) -- Not Used		
14000	Ammo/Other Material Handling Equipment (A/O MHE)		2.02
	14100	Projectile Storage and Transfer	2
	14200	Propellant Storage and Transfer	2.3
	14300	Fuel Storage and Transfer	2
	14400	Docking and Transfer Subsystem	2
	14500	Other Supplies Storage & Transfer Equipment	2
	14600	Ammunition Processing and Upload	2
	14700	A/O MHE Controls	2
	14800	RSV Enclosure Subsystem	2
	14900	A/O MHE Peripherals	2
	14A00	A/O MHE Product Support	2
	14B00	A/O MHE Product Development	2
15000	Command, Control, Communications and Crew (C3 & Crew)		4.2
	15100	Fire Control Sights Subsystem	4.2
	15200	Tactical/Technical Fire Control	4.2
	15300	DA Fire Control	4.2

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## Acquisition, Streamlining and Lessons Learned Report for Crusader

Self Propelled Howitzer (SPH) Resupply Vehicle (RSV)			Confidence 1=low;5=high
	15400	Data Display and Controls	4.2
	15500	Decision Aids	4.2
	15600	Video Distribution & Control (VD&C)	4.2
	15700	Interlocation Communications	4.2
	15800	Intravehicle Communication	4.2
	15900	Identification-Friend or Foe	4.2
	15A00	Navigation Subsystem.	4.2
	15B00	C3 & Crew Product Support	4.2
	15C00	C3 and Crew Element Product Development	4.2
16000	Vehicle Electronics Architecture		4.25
	16100	Data Distribution & Control Subsystem	4.25
	16200	Power Distribution & Control Subsystem	4.25
	16300	System Computing Resources	4.25
	16400	Operating System & Services/Executive	4.25
	16500	Vehicle Electronics Peripherals	4.25
	16600	Vehicle Electronics Product Support	4.25
	16700	Electronics Element Product Development	4.25
17000	SPH Communication/Identification -- Not Used		
18000	SPH Position/Navigation and Direction (NAV) -- Not Used		
19000	Survivability Suite		3.18
	19100	NBC and Environmental Control	3.16
	19200	Supplemental Ballistic Protection (SBP)	3.16
	19300	Non Ballistic Protection (NBP)	3.13
	19400	Fire Suppression	3.6
	19500	Defensive Armament(s) (DA)	2.75
	19600	DA Control Subsystem	2.75
	19700	Survivability Suite Product Support	3.3
	19800	Survivability Suite Element Product Development	3.6
1A000	SPH Survivability (SRV) -- Not Used		
1B000	Automotives		4.26
	1B100	Hull Structure Subsystem	4.3
	1B200	Suspension	4.5
	1B300	Power Package/Drive Train (PP/DT)	4
	1B400	Automotives Auxiliary Systems	4.5
	1B500	Automotives Controls	3
	1B600	Automotives Product Support	3.5
	1B700	Automotives Product Development	3
Resupply Vehicle -- Not Used			
SPH/RSV Common Elements (COMEL) -- Not Used			
Training, Support and Test (T/S/T)			3.9
41000	Training		no votes
42000	Peculiar Support Equipment (PSE)		no votes
43000	Common Support Equipment (CSE)		no votes
44000	Initial Spares and Repair Parts (IS&RP)		no votes
45000	Diagnostics and Prognostics		4*
46000	System Test and Evaluation (ST&E)		3.7
47000	Technical Publications		no votes
48000	Support Data		4*
49000	T/S/T Product Support		4
4A000	T/S/T Product Development		4
Peculiar Support Equipment (PSE) -- Not Used			

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

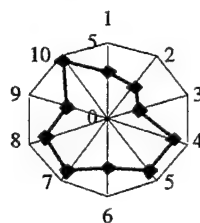
## Acquisition, Streamlining and Lessons Learned Report for Crusader

Self Propelled Howitzer (SPH) Resupply Vehicle (RSV)			Confidence 1=low;5=high
Common Support Equipment (CSE) -- Not Used			
Initial Spares and Repair Parts (IS&RP) -- Not Used			
Production			2.6
81000	Operational/Site Activation		3.5
82000	Industrial Facilities		3
83000	Production Product Support		2*
84000	Production Product Development		2*
Pgm. Control			4.8
91000	CITIS		5
92000	Data Depository (Pre-CITIS) (Not used)	not used	
93000	Common Development Environment		5*
94000	Data Management		4*
95000	Mgmt. Data		4*
96000	Eng. Data		4*
97000	Program Control Project Management		2*

\* in the table indicates only one "vote" cast for that item.

A Kiviat (Radar Plot) View of the major element confidence levels is summarized as follows:

1. System Development	3.1
2. Armament	2.58
3. Ammo/MHE	2.02
4. c3/crew	4.2
5. Vetronics	4.25
6. Survivability	3.18
7. Automotive	4.26
8. T/S/T	3.9
9. Production	2.6
10. Pgm. Control	4.77



### vi. Watchlist Recommendations.

Responses to candidate items for an IGCE Watchlist, to be maintained for the purpose of adjusting cost bases until negotiation, were provided as follows:

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

As the cost model transitions to ASCO, what are the PENDING developments, ambiguities, decisions or key events that we should include on our "Watch List" that could be a cost or schedule driver. Please list these items in enough detail so we can assess the area/WBS' affected and have your suggested points of contact.

WATCHLIST ITEM	WBS' IMPACTED	AREA OF IMPACT	PT.of CONTACT	NR VOTES
SCE/SOFTWARE CSCI	ALL	\$/SCHEDULE/SLOC'S	D. CARNEGIE, UD	4
CITIS LONGLINES CARRIER	CITIS-	\$	A. CASTELANO	2
NR. OF GUNS	12000/1210	\$	UD & D.	2
RA/CM MILESTONES/RVWS.	12000/1210	DRIVE IGCE	T. KURIATA-REP.	2
PASS-THRU AMTS.	ALL-WILL DRIVE MODEL	\$	PCO	1
Krs RED TEAM PROPOSAL	ALL	DRIVE IGCE		1
TRADE STUDIES-DET.AVOID.	19000/1930	DRIVE IGCE	R. SEVO/J.	1
TD. STUDIES-EARLY	19000/1930	DRIVE IGCE	R. SEVO/J.	1
TD. STUDIES-HIT	19000/1930	DRIVE IGCE	R. SEVO/J.	1
FY 97	1411	PROJ. ANTI-FRATR.	DR. P. LU-	1
FY 97	1421	LP STORAGE DEV.	DR. P. LU-	1
FY 97	1940	HALON REPLACEMT	M. RYZYI, 786-	1
COST OF SPARES	46000	EA. TEAM PRICED	W.L.SMITH-X5275	1
APU	1B400	NEEDED?	M. SMURLA	1
AUTO. CONTROLS	1B400-under 1B300	NOT BKN. OUT	M. SMURLA	1
RESUPPLY (ALL)	1400	DESIGN NEEDED	UD	1
MANPRINT LOE	1350	PRICED UD ONLY	D. GROSS	1
				1



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**E. Lessons Learned.**

**LESSONS LEARNED - IGCE TEAM SURVEY**

- Preparation for Action
  - A threshold level of detail from the contractor must exist. Until then, the team has nothing to estimate.
  - Computer resources, current editions of software, training, networking, and printing must be provided not later than the date when the estimating begins.
  - IGCE team's information architecture must be planned, debugged and rehearsed. Includes designs, formats, methods, frequencies, configuration control, and security.
  - The estimating approach must be decided (e.g., analogy vs. bottoms-up). Also includes assumptions such as travel costs and hours per month.
- Team Composition
  - Assign WBS elements to 5 to 10 teams based on commonality (e.g., Automotives, C3, SE)
  - Build teams with many personnel disciplines (e.g., cost analysts, engineers, specialists). Members must know their technology, process or discipline.
  - Create a review board to set guidance, resolve differences, cross-fertilize good ideas between teams. Board composition must also be multidisciplined with excellent talent.
  - Team leaders should be cost analyst since the product is a cost estimate.
- Estimate Development
  - Board conducts periodic formal reviews of team progress and assigns a readiness status to each team's estimate.
  - Strong effort is needed to generate and maintain communication between hardware contractor and IGCE teams, among teams and between teams and the review board. Close and constant review board involvement is essential to finding and fixing small problems before they explode.
  - Brief weekly information and feedback meetings are important.

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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**29. IGCE INFORMATION SYSTEM ARCHITECTURE PLAN.**

**A. Background**

The Information System Architecture Plan was developed during November 1994 by the support contractor, SAIC. IGCE Fact Sheets were drafted and, after revisions, were submitted to Mort Anvari for approval. The plan provided guidance by describing a system utilizing multiple database and application software to process data in a DOS/Windows environment resulting in detailed cost estimates and documentation. Estimates were supported by narratives, graphics, and schedules. The Information System Architecture Plan used a basic Input-Process-Output model with a Feedback mechanism. Each phase was described with the intent of providing IGCE team members sufficient guidance to work efficiently toward the IGCE completion.

**B. Input.**

The input section was comprised of four distinct areas: IGCE documentation, an integrated master schedule, an AFAS/FARV system fact sheet, and multiple subsystem fact sheets. Each of the seven IGCE functional teams were responsible for obtaining relevant data for the inputs. All team members were encouraged to back up data regularly. The use of font size 12 and Times New Roman font was the standard for IGCE completion.

**C. Documentation.**

In providing documentation, team members had to conform to software requirements as specified in the plan. Also, the plan explained data sources, estimating methodology, equations, groundrules, assumptions, and how the cost estimates were derived.

**D. Integrated Master Schedule.**

The Phase I and II integrated master schedule was created using information generated from each of the seven IGCE teams. Each team was responsible for providing SAIC with a chart listing task name, task description, and task start and end date on a bi-weekly basis. The data were then updated and integrated into the master schedule.

**E. System/Subsystem Fact Sheet.**

There was a fact sheet for the overall information system and for each element subsystem. The fact sheets followed the format of the CARD (Cost Analysis Requirements Document) as stated in DoD 5000.4-M. Each team was responsible for inputting the data described in the CARD Fact Sheet Outline to the fact sheets as it applied to the subsystem elements. If the CARD descriptions did not apply, it was not included in the fact sheet. Teams were responsible for providing the necessary data according to the specified format.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

### **F. Process.**

The Configuration Control Board (CCB) support consolidated the information provided by each of the IGCE functional teams and created integrated master files that each team could access. The CCB set the initial guidance, resolved differences, and cross leveled good ideas between teams. It also assessed the status of each team's estimate at formal reviews and then assigned a readiness status to each estimate, along with specific areas for improvement. The CCB was the communication facilitator for internal and external communications.

### **G. Compatible Software.**

To improve turnaround time, problems such as document conversions and incompatible file formats needed to be avoided. The following software requirements were used throughout the input, process, and output stages of the IGCE development effort:

- MS Office 4.2 (MS Word 6.0, Powerpoint 4.0, and Excel 5.0)
- MS Project 4.0
- MS Access 2.0
- ACEIT 2.2

The process previously described generated three "Outputs" during the IGCE work period. First, the process generated the actual cost estimates, schedules, and supporting narrative that the IGCE analysts required to accomplish their tasks. This was in the form of the Fact Sheets previously described. Second, the process generated a Procurement Contracting Officer Negotiation File which is described below. Third, the process generated a detailed briefing, which documented the IGCE for senior Department of Army Acquisition officials.

### **H. Procurement Contracting Officer File.**

The PCO's task is to negotiate a fair and reasonable Development Phase I and II contract. Considering time and resources available, the most effective information available to the PCO for this task is the information generated by the IGCE process. To assist the PCO, an information file was created which provides electronic and hard copy negotiation positions.

All IGCE functional teams were required to use the above software. A survey was also conducted to determine the current software the teams were using to ensure everyone was compatible. Anti-virus software was installed on every PC as well as a virus scanner on the file server that controls the Local Area Network (LAN).

### **I. Configuration Control Board (CCB).**

The CCB played a primary role in ensuring data integrity throughout the input, process, and output stages of development for the IGCE. Teams had access to master files by using assigned passwords on a read-only basis. Thus, changes to the master file were authorized only

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## Acquisition, Streamlining and Lessons Learned Report for Crusader

by members of the CCB. The IGCE master data files were set up so that they were protected from unauthorized access, modification, and intentional or accidental data loss.

### J. Data Base.

The database consisted of the USACEAC historical data relating to track and wheeled vehicles, current AFAS/FARV program data, and other data collected by SAIC. The Database documents at SAIC were copied and an AFAS/FARV IGCE library established at Picatinny Arsenal. All team members had access to the database via cc:Mail, which allowed them to read all of the master files.

### K. IGCE Library.

The IGCE library consisted of the database as well as supporting documents and reports, which assisted IGCE team members in developing their product. An electronic listing of titles and a brief summary was available on the IGCE LAN. The library was continually updated by SAIC with database information, current reports, briefings, and output information.

### L. Output.

The initial PCO File was constructed from the Fact Sheets generated by the functional and cost evaluation team members entered their own appropriate data.

	PCO	FILE	
SOW NUMBER			
SOW TITLE			
BRIEF WORK DESCRIPTION			
COST INFO (\$Ks)	CONTRACTOR PROPOSAL	GOVERNMENT ESTIMATE	DIFFERENCE
LABOR	XXX	123	XX
Engineering	XXX	234	XX
Technical Spt	XXX	235	XX
MISCELLANEOUS	XXX	234	X
MATERIAL	XXX	112	X
CAPITAL	XXX	345	X
OVERHEAD	XXX	234	XX
G & A	XXX	123	X
OTHER	X	1	X
TOTAL	XXXXX	56789	XXX
COMMENTS			



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**M. Supporting Documentation.**

This section of the Negotiation File provided the PCO sufficient information to justify the Government Estimate. It included assumptions, cost estimating relationships, actual calculations, and other information to assist the PCO. The PCO's negotiation team will document the final negotiating position after reviewing the contractor proposal.

**N. Lessons Learned.**

**LESSONS LEARNED - IS ARCHITECTURE PLAN**

- A copy of the outline for the fact sheets was taken to each team member. It proved unsatisfactory to provide one copy of the disk to each team because the configuration of the software and hardware and the familiarity of the individuals with the software varied widely. It was necessary to sit down with each person and ensure that they were able to use the outline.
- Virtually none of the team members were familiar with the outline and header features of MS Word. All of these differences were rapidly overcome and all teams were productive within a few hours.
- It is necessary to train the team on software and to use standard hardware and software.
- The process is an iterative effort with inputs being developed continuously, being processed, and added to the fidelity of the IGCE. This requires significant configuration control.
- The information and processes developed here, along with the skills of the IGCE Team, provided a strong foundation for follow-on negotiation support.
- The IGCE effort represents a considerable corporate body of knowledge which can be useful in future AFAS/FARV requirements (e.g., the IGCE team composition and management, Information System Architecture design and control, and estimating methodology, issues and presentation).
- The IS plan is the key to getting work done. Without the plan there are no processes, tools, procedures or communications.

**30. CRUSADER PRICING MODEL**

**A. Model Requirements**

The Crusader IGCE model requirement is best characterized as an estimating capability to support negotiation of a large development contract. The model had to be able to estimate labor and material category resources for a large number of WBS elements, and to estimate annual resource requirements, by resource category, for a period of five years. Labor hour estimates were required at the labor category level (i.e., for all labor categories expected to be included in

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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each labor burden pool), and these hours were priced consistent with the pricing procedures used by the individual hardware contractors. Additionally, a team of five contractors is performing the development effort and resource estimates for each WBS may involve one or more of the contractors. Beyond these requirements, was the estimator's need for flexibility to accommodate changes to the inputs, the WBS, and the contractors responsible for specific WBS elements. The model had to ensure that estimating methodology and rationale were always reflected in the estimated price.

Thus, the Crusader IGCE model estimating requirements demanded that the model include the features and flexibility to integrate a multi-dimensional estimating problem, those dimensions including:

- Estimation at WBS level four,
- Estimation by year,
- Estimation by contractor,
- Estimation by labor and material category,
- Pricing of resource estimates, and
- Linking of estimating rational and estimating calculations.

### **B. Model Structure**

The structure of the Crusader IGCE model can be characterized as follows:

- The workbook structure and spreadsheet structure within the workbooks is designed to model the WBS of the Crusader program. Spreadsheets represent individual WBS elements. Appropriate workbook and spreadsheet references within cell equations are employed to model the correct arithmetic relationships within the WBS hierarchy. A common labor and burden rate workbook is referenced by all cell equations that apply labor and burden rates.
- For each spreadsheet that represents a WBS element that is estimated (as opposed to those that represent totals and subtotals), a second spreadsheet is constructed to document the estimate rationale. These two spreadsheets are linked through appropriate cell referencing, and this reinforces consistency between estimate and documentation.
- Within each spreadsheet, contractor estimates are arranged vertically. Within a contractor estimate, individual spreadsheet rows are used to model the contractor's accounting structure (i.e., individual direct labor and material, and indirect burden categories).
- Yearly estimates are arranged horizontally within spreadsheets. Within each yearly estimate we display: direct resource estimates (i.e., labor hour and material dollars),

**Additional Lessons Learned, Updating, and Notes for Crusader**

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direct labor and indirect burden rates, and the resulting dollar estimate (obtained by applying the labor and burden rates to the direct resource estimates).

### C. Decentralized Input and Analysis

To ensure the accuracy of the estimate, it was critical to remove the possibility that any estimator would accidentally alter the model's pricing calculations. The teams were given templates in which the only unprotected cells were the ones designated for data input by the user.

Because the model evolved along with the estimate, the IGCE IPTs were given new versions of the model in which to record the next iteration of their estimate. Substantial effort was required to ensure that each team received a current and correct version of the model. Configuration management of the model, incorporation of each estimate, and protection of the data were the implied tasks of producing the estimate. It was critical that the process of distributing the segments of the model and incorporating the updated estimates be as simple and error free as possible.

CRUSADER PRICING MODEL TEAM GUIDELINES
<ul style="list-style-type: none"><li>• All data entries must be in whole dollars and hours.</li><li>• Hours and dollars must be estimated by fiscal year.</li><li>• Each sheet should be protected against entry except in the input cell areas.</li><li>• Work with model on hard disk is recommended rather than on the floppy disk.</li><li>• Daily data back up is recommended.</li><li>• If total WBS dollars are estimated then no hour or dollar value estimates can be made at the lower levels.</li><li>• Pay specific attention to which contractor heading is displayed when scrolling through the sheets and inputting data.</li><li>• Double check all input for accuracy.</li><li>• Answer "no" to the question, "do you want to reestablish links?" when the model appears on the screen.</li><li>• All inputs to a file should be made in a single copy.</li><li>• The team leader is responsible for keeping a current, consolidated file.</li></ul>



### D. Documentation of the Estimate

The ability to amply document each estimate was absolutely essential for the IGCE. The final report was to be used by negotiators who were not part of the IGCE team and who would be using the report as a basis for negotiation. The estimate, all assumptions, sources, and calculations had to be explicitly presented.

It was also considered necessary to dynamically link the documentation and calculations of the estimate to the cost structure elements in the model. This feature would allow instant pricing of changes in the estimate worksheets. It would also ensure that documentation and the

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

estimated price were synchronized. Disconnects between the estimated price and supporting documentation would destroy the government negotiating team's credibility and undermine success in reaching a mutually beneficial contract agreement.

### **E. User Friendliness and Editing**

The Graphical User Interface (GUI), makes the model easy to navigate. The on-screen templates are clear and can be infinitely tailored for specific purposes. This capability was critical to developing a model that was partitionable along the lines of the management approach used in the Crusader program. Such partitioning gave the user a clear match between the work being performed and the estimate being developed.

The IGCE material covered a broader scope than the calculation of the estimated cost in the spreadsheet. Fact Sheets were developed (in Word) to capture information in the Cost Analysis Requirements Description (CARD) and the Contractor's Draft Proposal for program phases I and II. Our briefing presentations (done in Powerpoint), were constructed by pulling the graphics, tables and documentation from within the Excel model. The requirement for the documentation, calculation and presentation was known from the beginning of the IGCE effort. The ability to move information from one domain to another as easily as possible proved to be an important capability throughout the process.

### **F. Graphic Representation and Printed Documentation**

The IGCE team used several charts to depict various aspects of the estimate at the top level. At lower levels, graphics were rarely used, although the initial expectations were that all levels would use this capability. As it turned out, with the relatively small number of charts, the links between data and graphs were not critical to the model. However, the links clearly made graphing much faster and could have been essential if the amount of graphing had been higher.

The composition of the contractor team imposed a requirement to be able to display the cost accounting structure of each of the five companies, for each of the five years, for each of the reportable elements. Additionally, the rate calculations for each team member had to be shown. This information was unique to each contractor, but was repeatable for each WBS element.

The documentation of the estimate, however, varied among the WBS elements. No two were identical. The ability to tailor printouts for content, shape and appearance was critical to accommodating the diversity in this model. The outline capability was useful in some cases. Macro commands to accomplish the printing are an option but were not written for the IGCE. Print macros should be a part of a widely distributed model.



**Additional Lessons Learned, Updating, and Notes for Crusader**

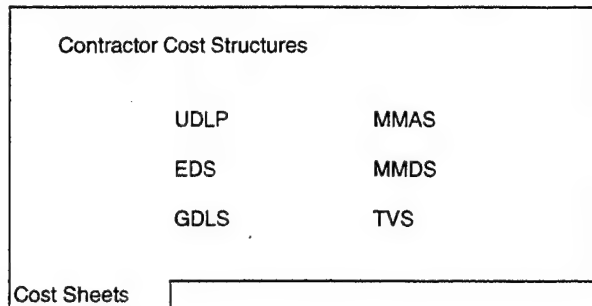
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**NOTES**

## G. IGCE Model Outline.

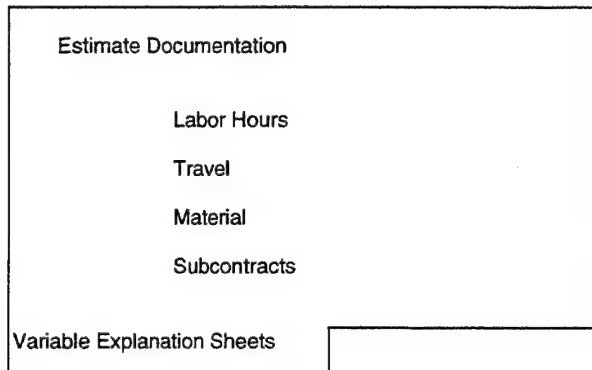
### i. Overview



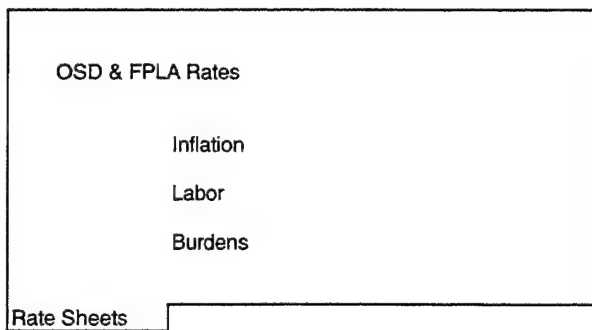
One set of sheets exists for each of the 82 reportable WBS elements.

The Cost Sheets pull rates from the rate sheet and the estimate values from the VESs.

Estimates are in '95 constant dollars.



All assumptions and calculations are fully documented in the VESs and electronically linked to the cost sheets.



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

# Acquisition, Streamlining and Lessons Learned Report for Crusader

## ii. Contractor Cost Sheets and Variable Explanation Sheets.

WBS COST OVERVIEW										
ROLLUP		FY '96		FY '97		FY '98		FY '99		FY '00
Contractors' Labor Element Structures	UDLP	UDLP		UDLP		UDLP		UDLP		UDLP
	GDLS	GDLS		GDLS		GDLS		GDLS		GDLS
	MMAS	MMAS		MMAS		MMAS		MMAS		MMAS
Protected	MMDS	MMDS		MMDS		MMDS		MMDS		MMDS
	TVS	TVS		TVS		TVS		TVS		TVS
ROLLUP		14100	14200	.....	14100 VES	14200 VES	.....			

14000.XLS      Reporting Levels      Variable Explanation Sheets  
 Ammo/Other Material Handling Equipment

ROLLUP sheets give the summary costs at level 3 WBS elements, e.g. 14000.

Reporting Level sheets calculate the costs from the input variables.

Variable Explanation Sheets contain input values for labor, travel and material.  
 The derivation of these inputs is also provided.

All sheets are electronically linked for automatic recalculation.

WBS VARIABLE EXPLANATION SHEET	
<u>Description of How Estimate Was Derived</u>	
<u>Assumptions (Includes / Excludes)</u>	
<u>Calculations</u>	\$
<u>Sources</u>	
<u>Annual Distribution</u>	<u>Contractor Distribution</u>
%	%
14100 VES	

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

# Acquisition, Streamlining and Lessons Learned Report for Crusader

## iii. Supporting Sheets.

OSD INFLATION FACTORS		FY '96	FY '97	FY '98	FY '99	FY '00
Protected	UDLP	UDLP	UDLP	UDLP	UDLP	UDLP
	GDLS	GDLS	GDLS	GDLS	GDLS	GDLS
At ROLLUP level: e.g. 14000	MMAS	MMAS	MMAS	MMAS	MMAS	MMAS
	MMDS	MMDS	MMDS	MMDS	MMDS	MMDS
Annual Values	TVS	TVS	TVS	TVS	TVS	TVS

RATES

Rates are given for:

Labor  
Overhead  
G & A  
Fee

Program Dollar Summary for 14000						
	Total	FY '96	FY '97	FY '98	FY '99	FY '00
14100						
14200						
14300						
14400						
14500						
TOTAL						

SUMMARY

ROLLUP and SUMMARY sheets are also provided at the Program Level.

Graphs are provided at the Program Level.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**H. Lessons Learned.**

**LESSONS LEARNED - CRUSADER PRICING MODEL**

- Configuration control is critical. The model evolves with the estimate. One central point must ensure that teams use only the current version for their estimates.
- Virus checking and protection are essential since disks from dozens of machines and sources are involved.
- Meticulous tracking of changes to the estimate is needed for confidence that no errors of logic, computation, or data entry have occurred. All users and reviewers of the model should receive a high level conceptual overview of its purpose, layout and function.
- Built-in adaptability is necessary to accommodate any unplanned changes to contractor teaming or rates; to WBS, SOW or dictionary; or to IGCE requirements such as team realignment and analysis of risk.
- In order to run the model effectively, computers should have at least 8 MB of random access memory (RAM).
- All team members must utilize the same version of Excel, and any other software packages being shared.
- Be extremely careful when cutting and pasting items from other Excel workbook sheets into a model file. If not careful, a model file may be corrupted by unexplainable links to inappropriate sources.
- Computers must have enough hard disk space free to accommodate a current version of all applicable model files (file size varies by WBS element).

**31. CONFIGURATION CONTROL BOARD.**

**A. Purpose and Findings**

The first Configuration Control Board Meeting of the IGCE convened on December 8, 1994 at Picatinny. The meeting was called to order at 0900 hours by the IGCE Team Chief. The purpose of the meeting was to discuss the initial Fact Sheets that were drafted by each IGCE functional team. There were seven teams represented at the meeting. The technical leader from each team presented their team's Fact Sheet data. The following is a summary of issues and action items discussed:



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

#### **FIREPOWER**

- The primary/support areas of the WBS team matrix were agreed upon.
- The data sources used for the Fact Sheets were the Program Office Estimate (POE) and RLPG proposal.

##### **Action Items**

- Standardize CARD outline.
- Because of other team support to the WBS matrix, attendance would be required at the other functional teams' CCB meetings.

#### **MOBILITY**

- The primary/support areas of the WBS team matrix were agreed upon.
- The data used for fact sheets were POE, CARD.
- Concerned with use of data from turbine engine vs. diesel engine.

##### **Action Items**

- Fact Sheet data need to be in CARD outline format.
- Correct data flow problem from TACOM.
- Need broad representation on the board.
- Can't be seen as just a means to force an answer or to slave drive the IGCE. IGCE members must know that CCB is there to control fair assumptions and processes, and integrate results

#### **LOGISTICS AND RESUPPLY**

- The primary/support areas of the WBS team areas were agreed upon.
- No fact sheet was presented.

##### **Action Item**

- Fact sheets will be developed.

#### **SYSTEMS ENGINEERING AND INTEGRATION**

- Primary responsibility for MANPRINT will be moved to Project Management - all other areas remained the same.
- The POE was used to develop data for the fact sheets.

##### **Action Item**

- Continue further development of Fact Sheets.

#### **COMMAND, CONTROL, AND COMMUNICATIONS**

- The primary/support areas of the WBS team matrix were agreed upon.
- The POE was used to develop the Fact Sheet data.

##### **Action Item**

Continue development of Fact Sheets.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**PROJECT MANAGEMENT**

- The primary/support areas of the WBS team matrix was agreed upon; MANPRINT became a part of this team's matrix.
- The POE was used as a data source for the fact sheet; the Government Concept of Operations was recommended as a data source.
- This team's WBS was considered a very high risk due to being primary support for all IGCE teams.

**Action Item**

How to cost the PM effort; how, and when is overhead applied.

**CCB ACTION ITEMS**

- COL Pawlicki was to ensure that a letter was sent to Project Managers and Major Commands identifying the IGCE's purpose and why data were needed from them. Team leaders would follow up with specific requests.
- Definition of the Red, Amber, Green status codes of the fact sheets was to be published. A percent complete determination was also to be made with SAIC drafting the criteria.
- With EMD and Production quantities, all differences must be costed because it directly impacts the unit cost.

**B. Lessons Learned.**

**LESSONS LEARNED - CONFIGURATION CONTROL BOARD**

- How best to cost the PM effort and when is overhead applied.
- Fact sheet data need to be in CARD outline format.

**32. DATA GATHERING ASSISTANCE.**

**A. Background and Approach**

Because of problems in trying to get information and data by the IGCE Team for the seven functional teams, Mr. Dale G. Adams, Project Executive Officer for Field Artillery Systems signed a memorandum on 16 December 1994 to other PEOs for assistance on a data call for the Advanced Field Artillery System and Future Armored Resupply Vehicle IGCE. The memorandum was sent to MG John Longhouser, PEO, Armored Systems Modernization; MG Dennis Benchoff, CG, US Army Industrial Operations Command; and BG Edward L. Andrews, CG, US Army Tank-Automotive and Armaments Command.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**B. Lessons Learned.**

**LESSONS LEARNED - DATA GATHERING**

- Program Executive Offices, Project Manager Offices, and Product Management Offices personnel should be made aware of an IGCE exercise prior to the beginning of such an effort and be willing to provide information/data when requested.
- The involvement of a services contractor with access to contractor labor rates, in this case SAIC, requires disclosure/non-disclosure agreements, which must be worked well in advance.

**33. IGCE TEAM VISIT TO UDLP**

**A. Background**

The IGCE Team visit to UDLP had been scheduled for 29-30 November, 1994, but was changed to 14-15 December 1994 because of RACM negotiations between the PCO and UDLP. The PM did not want the visit to impact the RACM negotiations. Prior to the visit, on 12 December, the UDLP project manager, Paul Eskritt, faxed a message to COL Pawlicki requesting that the visit to UDLP take place in during the first part of January as that would be best time for them. With the postponement of the 29-30 November scheduled visit to UDLP, until early January, the IGCE Team was slowed in trying to document or review data (without data cost from UDLP) and in developing WBS costs.

**B. Functional Team Reports From the UDLP Visit**

*i. Firepower Team.*

Each of the Firepower Team members was provided with a package of material which included schedules, component maturation plans, firepower WBS, and issues to be integrated into the IMP/IMS. Literature was also received on turret design, weight allocations, risk assessments and design plan. After reviewing the material, analysts met with various engineers from UDLP and discussed WBS items in detail and what systems they were basing their estimates upon. A trip was planned for the following week to Pittsfield, Massachusetts, to visit and obtain/confirm data from Martin Marietta Defense Systems on the RLPG. A cost analyst and an engineer from the IGCE Team made the visit. The visit proved valuable and detailed information, which was lacking from UDLP, was obtained to assist in developing better cost estimates.

*ii. Survivability Team.*

UDLP provided a package to each member of the IGCE Team. Included was general information, as well as specific information that UDLP is planning for each survivability suite

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element during each phase. Each Element in the WBS was assigned to a member of the IGCE Team for developing estimates.

### *iii. Project Management Team.*

The team met with Paul Eskritt, the project manager for UDLP and discussed elements of 90000, Project Control, concerning direct charges and G&A charges. The project element managers are considered G&A, while the PDT leads are direct charges. Contractor Integrated Technical Information Service (CITIS) costs include data management only. Data creation is carried under its own WBS. Equipment purchased by EDS, as directed by UDLP, is Government-owned and is justified under the Warner Amendment and is charged as a direct cost. WBS 93000, the common development environment, is an environment where the subcontractors can use each other's data. An example is all contractors using ProEngineer for CAD/CAM which includes training software and hardware if necessary. CITIS cost includes computer architecture, software, telecommunications, training, customer service, some database administration, and systems and network management. EDS will establish CITIS while the prime and each subcontractor is responsible for its own user support staff. EDS provides technical and architectural support. WBS 80000, production, will involve site construction/conversion and other manufacturing planning. The idea is to integrate producibility as a driver in the design process. Project control included subcontractor management.

### *iv. Resupply/Logistics Team.*

The UDLP resupply/logistics team meeting started with the resupply concept that what they are now proposing may not be the same in the near future. Following this, the IGCE Team was presented a reasonably detailed review of the potential configuration of the major WBS elements comprising the Ammunition/Other Material Handling Equipment (A/O) MHE system. The IGCE Team asked for a description of the major efforts and time phased schedules that were presently contemplated to reach major milestones (e.g., PDRs and CDRs). They had not established any and stated that this would be done during the first year after contract award. They were planning to subcontract approximately 40% of the work and for developing their cost estimates, the ARM I and ARM II programs as guidelines. The IGCE Team was denied any access to historical cost information and insisted it come from the PM's office. Based on the above, the resupply function cost estimate will be accomplished through a parametric approach using POE and ARM I and ARM II historical data. Logistics data were provided with an updated WBS breakout along with a proposed change. Also provided was a Product Development Team breakout. Logistic requirements, process, and approaches will be distributed across all levels of PDT support. From an IGCE perspective, this means WBS elements that have Logistics Support Analysis (LSA), MANPRINT, or training will have to be rolled up into an overall cost estimate. Information to form a concise reasonable cost estimate is not available. UDLP agreed and will do parametrics where it fits and estimate where it doesn't fit. UDLP has focused on the AGS Project for the majority of logistics concerns. They are also pursuing Comanche and Bradley for comparison data. The IMP/IMS will not be available until after contract award.



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### v. *Mobility Team.*

The UDLP members provided data and information concerning their system level guidelines and directives, baseline concept drawings, latest WBS, WBS dictionary, draft SOW, product development process (overview), and project schedules. UDLP will evaluate steel and aluminum in the hull structure, 1-inch steel and 2-3/8-inch aluminum as the likely candidates. TVS would have the responsibility for this element. GDLS would be utilized as a subcontractor and would be responsible solely for fabrication. Discussions were held with the System Development Team (SDT) regarding UDLP's approach for VETRONICS. Based on these discussions it was understood that VETRONICS may be incorporated under the System Development area. They will develop the system level requirements for the on-board control stations and software and then interface with the individual product teams for development of the specific controllers included in each product design. All software and hardware needed for the control and operation of the Automotives system and subsystems will be included in the appropriate Automotives WBS elements. The FAS mobility development schedule provided by UDLP details Phase III prototype development work beginning the first quarter of 1997. The extent of this work cannot be identified by the information provided, nor was it anticipated to cost this level of effort during Phase I and II.

### vi. *Command, Control and Communications (C3)/Crew Team.*

Based on the visit to UDLP, some of the findings that were not evident from the earlier versions of the WBS dictionary are: the C3/Crew Team has the full responsibility in the development of the crew stations. Crew station development will not only include crew displays and controls but it will also involve the development of crew support equipment that provides vision devices, seats and restraints, crew compartment lighting, integral ration/water heater, etc.; all cameras (or video sources), with the exception of fire control sights and cameras unique to other subsystems, are the responsibility C3/Crew Team; there are a number of vehicles that will support the Crusader development efforts. These include surrogate vehicles, crew module(s), truck, and demonstrators that might be within the System Integration Facility (SIF). A description of these vehicles was requested and will be provided. This description will allow for the determination of the level of involvement and responsibilities of the C3/Crew and Electronics Teams. The Vehicle Electronics team is responsible for satisfying and providing the processing needs of all subsystem development efforts (Phase II and limited prototypes and objective system electronics). Although the limited prototypes will consist of off-the-shelf hardware only, the architecture and operating system will be that of the objective system. It is anticipated that approximately 30 processor boxes will be made available by the Vehicle Electronics Team to support various software development activities. Additional hardware may be needed to support other development efforts (e.g., development vehicles mentioned above).

Vehicle Electronics development efforts will primarily consist of: requirements analysis; functional decomposition; simulation and modeling for concept development; concept development; behavior modeling and performance modeling (which will verify system loading and influence functional partitioning of the architecture and will be used to verify the concept developed in concept development). The output of the Vehicle Electronics activities, with

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respect to the objective system design, will consist of Prime Item Development Specification (PIDS), validation and demonstration of electronics concept through SIL, and validation and demonstration of the operating system.

Information obtained from UDLP was: preliminary Crusader Dem/Val WBS; dictionary for WBSs 15000 and 16000; SOW; IMP accomplishment criteria outline; team AFAS Dem/Val operational concept; and material list for AFAS/FARV for all electrical devices being considered in time for the objective system design, which includes a printout of schematic diagrams. Information requested was: object-oriented system architecture layout; software source line of code estimate; priority list/order of development efforts for various software/hardware builds; description of various development vehicles used (e.g., surrogate, crew module).

It appears that details of subsystem development efforts, although known at the PDT level, have not been coordinated and communicated with the upper system level development teams and activities. Therefore, a careful review of the Blue Team proposal will be required to confirm the finding of this meeting with what is being proposed.

vii. *Systems Engineering and Integration Team (SEIT).*

In meeting with UDLP managers, the IGCE Team members were briefed on the correlation of the PDT's function with SEIT. The system engineering will be difficult to cost because its elements are spread across the various PDTs. For example, MANPRINT has a separate level 5 WBS under each product. UDLP estimates SEIT costs to be about 10% of the total project. UDLP plans on using a bottom-up approach for the first two years and PRICE X from the top-down followed by a sanity check. The System Integration Facility (SIF) will be established in a portion of the plant facility where similar efforts were conducted for other programs. The Software Systems Integration Laboratory (SIL) will be established as a part of the SIF and will be physically located in a controlled environment close to the SIF. The SIF will be used to assemble integration hardware for integration and assembly analyses and to perform integration testing. The facility will also be used to fabricate the two AFAS/FARV prototypes as well as the automotive test rig. Current heavy lift equipment and associated assembly tools will be used. Special requirements for this phase have not been identified.

The SIF will use only UDLP technicians and engineers. Approximately 25 technical personnel will operate the SIF on a routine basis. PDTs are developing their own estimates for prognostics/diagnostics for the UDLP proposal and will include them in their individual proposals. UDLP will hire a services contractor to support this effort (8-10 personnel). Integration testing is expected to be conducted at the system level using the SIL and the SIF. Dem/Val WBS, WBS dictionary, and WBS SOW were received from UDLP.

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**C. Lessons Learned.**

**LESSONS LEARNED - IGCE VISIT TO UDLP**

- Majority of the concepts were not yet mature, necessitating frequent follow-up by team leaders. This resulted in some of the estimates being based on analogous systems (e.g., the AGS, Paladin, Bradley Fighting Vehicle [BFV]). By May/June 1995 more empirical data became available to improve the IGCE.
- There was a better understanding of the program and UDLP plans as a result of the visit. There was no substitute for face-to-face information.
- Exchanges between the contractor and the IGCE teams.

**34. SCARCE DATA/INFORMATION**

**A. Proprietary Information.**

Even after the tour to UDLP, information was still scarce and slow coming from UDLP. One of the problems was that UDLP required that information, especially proprietary information, be controlled. After calls from COL Pawlicki and COL Sheaves for information support, and a memorandum from the PCO to UDLP, a letter was received by the PCO dated January 16, 1995 from UDLP.

**B. Letter from UDLP.**

The letter was in response to the Government's request for permission to release UDLP's proprietary financial data contained in the 15 Dec 94 proposal. UDLP recognized the importance of supporting the IGCE and authorized release of the information to SAIC and the Government with the following provision:

Financial data shall be released only to those SAIC employees from the Cost and Acquisition Management Operations Division with a "need to know" in order to carry out their respective duties in connection with the Government's Independent Cost Estimate Team for the AFAS/FARV Phases I and II proposal.

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**C. Lessons Learned.**

**LESSONS LEARNED - SCARCE DATA/INFORMATION**

- All team members must sign non-disclosure agreements early and forward to contractor. This should include "need-to-know" statements.
- It can take several weeks and senior management attention to execute non-disclosure agreements among all the contractors.

**35. IGCE SPECIAL EVENTS**

**A. SOW Date Change.**

At a special meeting held at the AFAS/FARV PM office on 19 January 1995, the IGCE Team was informed by COL Pawlicki, the IGCE Team Chief, that the proposal from UDLP would be delayed for six months, but instructed each systems team to continue with the cost estimates and to meet at the 17 February 1995 briefing to the AAE. UDLP was unable to meet the schedule because of the uncertainty of various aspects of the RFP. Once awarded, the project will pursue a streamlined acquisition approach consisting of a single, three-phase development cycle in place of the traditional Demonstration and Validation (Dem/Val, now Phases I and II) and Engineering and Manufacturing. COL Pawlicki's concern was with what could be done with the four tasks required by the contract with SAIC. Also, COL Pawlicki needed to meet with the PCO and find out what his new requirements would be based on the delay. The following was the new proposal schedule:

*i. New Proposal Schedule*

JAN	FEB	MAR	APR	thru	SEP	OCT	NOV
		MOD I					PHASE I
ENGINE		PROPOSAL					
BRIEF			RACM				
			DEF'N				
		IGCE			MOD 2		
		COSTS			PROPOSAL		

**B. IGCE Reviews**

On 2 February 1995, a memorandum was distributed to all members of the IGCE describing two reviews of the completed WBS and associated costs that were scheduled for the weeks of 8 February and 14 February. The purpose was to increase confidence in the final product and to communicate the methodology and calculations applied to create the estimates.



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### *i. CCB Team Review.*

This review was held 8 - 10 February with the CCB spending approximately half a day conducting an internal review of each team's product. COL Pawlicki, Mort Anvari, and Kevin Holmes reviewed each team's estimate during the team briefs. Each team briefed their general methodology and data sources on the development of several of the reporting level WBSs selected by the CCB. Each team was also required to describe any additional short-term efforts which would enhance the IGCE. During and after the briefing, the CCB directed actions to improve the methodology or the processes used in the cost estimates.

### *ii. Quality Review.*

This review was a critical analysis of the complete Draft IGCE by an experienced panel of Cost Analysts from the Army and SAIC. Each panelist was provided a draft copy of the appropriate team's WBS and VES prior to each half day review. This enabled the panel to talk with members of each team and to reach a consensus on any issues and recommendations. This resulted in value-added improvements to each team's product. Members of the panel were Mort Anvari, USACEAC; Kevin Holmes, ARDEC; Michael Niggel, SAIC Vice President, Washington, DC Operations; and Harold Rafuse, SAIC Vice President, Detroit Operations.

### *iii. PM's Business Manager.*

As a result of the reviews, the Crusader project showed a shortfall of \$110 Million for FY 96 and FY 97; however, excess funding was available in the outyears of the project. The only logic to explain this dilemma was that the PDTs were not funded up front vice later years when their efforts would realize savings to the Crusader project. COL Pawlicki met with Mr. Charles Mattingly, the PM's business manager to see what could be done to fix this problem. The result of the meeting was: (1) to ask for more funding (which was not feasible with the two budgets already before Congress), or (2) to cut back, or make trades on various aspects of the project (e.g., six prototypes vice 10, shorten testing).

COL Pawlicki called the IGCE Team together the same day and discussed the problem. He asked each Engineer and Analyst to look at their programs and try to reduce the shortfall for the two years. He specifically asked for "what if" drills, lower cost options, and what he called his PM's Watchlist consisting of the following:

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### PM'S WATCHLIST

- Potential for Double Counting with Product/Process WBS
- Spares for System Level Testing in PDTs
- Negotiate a Lower Pass Through Rate 30%-10%
- Soft Tooling may not be Adequately Covered
- Software Capability Evaluation (SCE) - Completed end of April or Early May Indicates Change is needed in SW Strategy

Shortly thereafter, the shortfall for FYs 96 and 97 was no longer a problem. Through the PEO's funding flexibility, adjustments were possible through other PEO managed programs.

### C. Lessons Learned.

#### LESSONS LEARNED - IGCE SPECIAL EVENTS

- Early resolution of issues common to all estimating teams is critical to building momentum, eliminating false starts. There should have been more discussion and writing of procedures to be followed at an early stage in the process.
- The Schedule Milestones established for review, with Red/Green/Amber ratings, were effective.
- Delayed contact with UDLP (from November to January) lost momentum and nearly halted progress during that period. The late availability of the detailed UDLP plans reduced the confidence in early estimates and necessitated a strong effort to develop the final estimate as quickly as possible.

## 36. IGCE STATUS BRIEFING TO THE PEO AND TO THE AAE

### A. Background

On 3 March 1995, COL Pawlicki and Mr. Neuman briefed the current status of the IGCE to Mr. Dale Adams, the PEO and COL William Sheaves, the Crusader Project Manager. The briefing went extremely well with no change in direction of the IGCE project. COL Pawlicki was scheduled to formally brief Mr. Robert W. Young, Director, U.S. Army Cost Center on 8 March 1995 at the Cost Center. However, because of time constraints, COL Pawlicki had to discuss the IGCE informally with Mr. Young who agreed in principle with the concept of the recommended project.

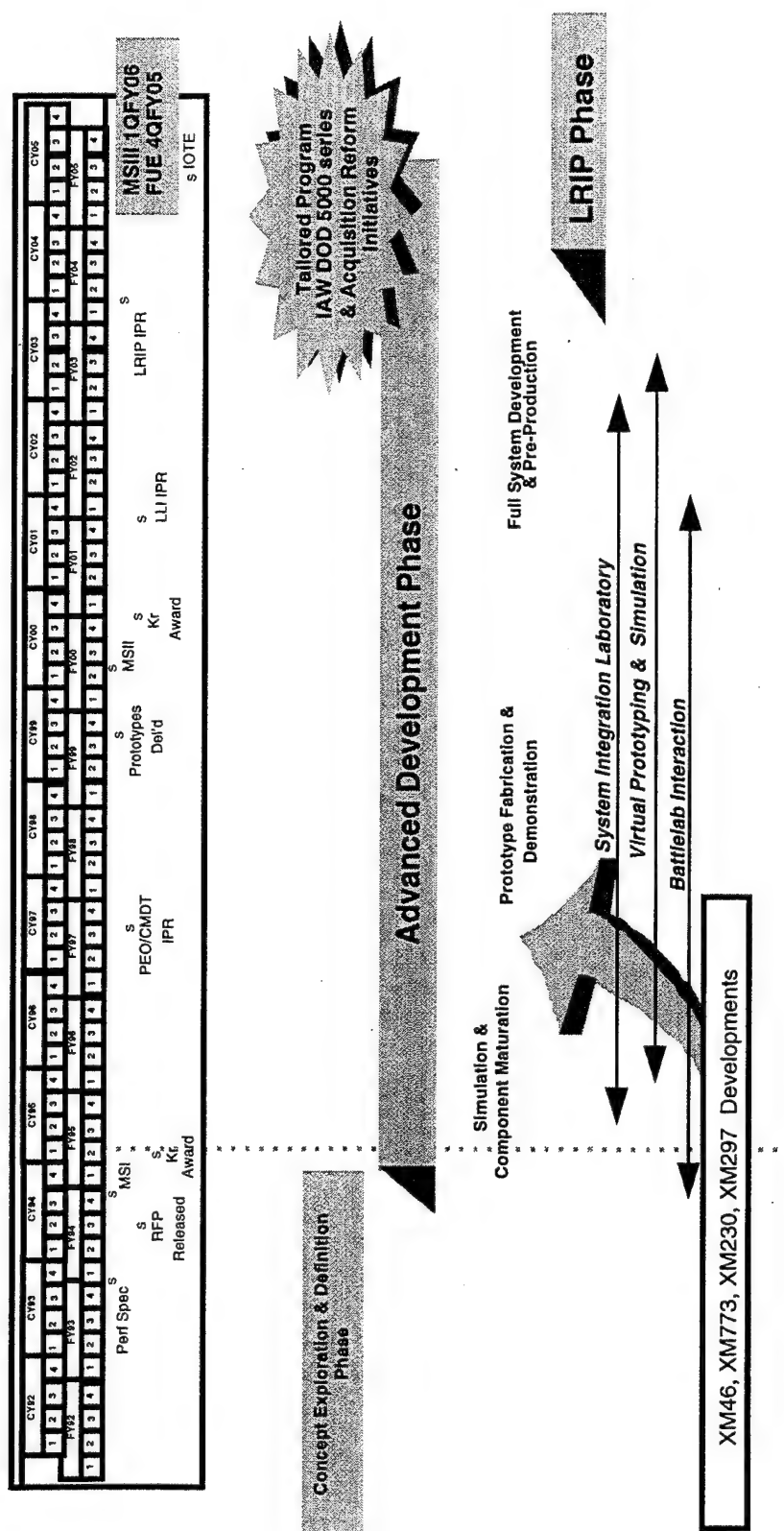
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**B. Crusader Project Schedule.**

Shown below was the new Crusader project schedule as a result of the PM's coordination with UDLP.

**C. IGCE Cost Estimates Sensitivity.**

Because the IGCE was nearing completion and IGCE cost estimates were now being finalized, COL Pawlicki assembled the IGCE teams together on 7 March for a short talk concerning cost data. He emphasized that all information regarding the team's efforts, to include any excess working papers, should be shredded since all of it contains contract sensitive information. Papers and data that will be needed by the PCO will be stored in a locked metal cabinet and will be kept at the ASCO for safekeeping. COL Pawlicki emphasized that U.S. Codes provide for heavy fines and/or imprisonment for not safekeeping the IGCE cost estimates and other sensitive information.

**D. Summary of AAE Briefing, March 16, 1995**

*i. Title*

The Title is "Crusader Independent Government Cost Estimate for Demonstration Phases I and II - Decision Briefing to the Honorable Gilbert Decker, Army Acquisition Executive, by COL Ray Pawlicki."

*ii. Purpose*

- Provide the results of IGCE for Crusader Development - Phases I and II
- Obtain AAE approval of IGCE process and estimate as the initial Army contract cost position

*iii. Goal*

The goal is to provide a robust IGCE to the PEO and PCO which establishes the baseline for negotiation of the Crusader Demonstration Phase I and II contract by providing cost estimates, trade-offs, and risk analysis for the projected work scope.



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### *iv. Organization*

- Director's Office
  - Estimating Teams
    - ◇ Firepower
    - ◇ Resupply and Logistics
    - ◇ Mobility
    - ◇ Systems Engineering Integration
    - ◇ Survivability
    - ◇ Program Management
    - ◇ C3

### *v. Conclusions*

- The Army has a robust and supportable IGCE to support negotiation of the Crusader Dem/Val Phase I and II contract.
- Additional work is required to maintain the IGCE through the continuing proposal development and delivery.

### *vi. Recommendation*

The recommendation is to approve the Crusader IGCE process and cost estimate as the initial Army contract cost position.

### *vii. Results*

- Briefing well received.
- PEO to "notify: AAE of final IGCE numbers.

## **37. RA/CM EXTENSION (RACMe)**

### **A. Introduction**

This Independent Government Cost Estimate (IGCE) was an analysis of the extension to the Requirements Analysis / Component Maturation (RA/CM) contract for the Crusader program. The draft Statement of Work (SOW) and Work Breakdown Structure (WBS) available on March 21, 1995, were used to prepare the cost estimate. A video teleconference (VTC) between the contractor and government representatives on March 22, provided additional information. The target for completing the estimate was March 31. The period of performance for the RA/CM extension was assumed to be August 1, 1995 to December 31, 1995.

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### **B. RACMe Preparation**

To prepare the Extension IGCE, sections of the SOW were allocated to government team leaders who had worked on the baseline RA/CM and the Phase I & II IGCE. These Team Leaders, working with supporting technical and cost analyst staff, prepared an estimate of direct labor hours, material, and travel costs for each element in the SOW. They documented the development of their estimates in Variable Explanation Sheets (VES). This information was entered into a spreadsheet model developed by SAIC, the supporting contractor, to determine fully-burdened cost estimates for each of the elements. The model is an adaptation of a larger model used in the Crusader Phase I and II IGCE.

The model, built in Excel software, includes labor rates by burden pool, G&A, and Fees for each of the six major contractors involved in RA/CM. These include: United Defense, Lockheed-Martin Defense Systems, Lockheed-Martin Armament Systems, General Dynamics Land Systems, Teledyne Vehicle Systems and Electronic Data Systems. The model accepts data from each of the IGCE teams, calculates a price for each element and creates roll-up tables and graphs as needed.

Labor and overhead rates are based on Forward Pricing Rate Agreements (FPRA) for UDLP, GDLS and MMDS. No FPRA were available for MMAS, EDS or TVS at the time of the estimate, and contractor proposed rates were used in these cases. The base to which individual overhead rates are applied are displayed on the pricing formats for each WBS and company. An eight percent fee is assumed in all cases.

### **C. A RACMe Model Was to Build the RACMe Basis-of-Estimate**

During May, 1995, the PMO Team was developing a RACMe Basis-of-Estimate (BOE) with the engineers at UDLP. On May 30, PMO delivered a two volume set of documentation that comprised the BOE. The IGCE Team was to cost the RACMe BOE using the same model that had costed the IGCE. The PMO had initially used one set of burdened rates for TVS and another set for all other contractors. The IGCE model provided a better estimate by using more accurate rates. An accurate estimate of the BOE cost was necessary for comparison to the available funds.

The BOE negotiation documentation contained the detailed estimates of labor, materials, subcontractors, and travel for the RACMe SOW. One volume had been prepared at UDLP in Minneapolis and covered all work except for the D1200 and D1400 WBS elements. The second volume was prepared at MMAS in Pittsfield and covered the other two WBS elements.

The assumption was made that 40% of the work took place in FY '95 and 60% of it took place in FY '96, a flat level of effort for the five months of RACMe, August through December of 1995. It was noticed that the Pittsfield estimates only included MMAS, not any prime contractor effort by UDLP. Brian Churchman provided the missing estimates and these were

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included in the estimate. The results were provided to PMO on June 1. The RACMe BOE price was compared to the RACMe IGCE and to the available funds for this phase of the program.

The WBS used by the contractor for this effort is the following:

- 00000 Crusader System
- 90000 Crusader System Program Management
  - 91000 Systems Engineering
    - 91100 Systems Engineering
    - 91C00 Firepower
    - 91D00 Resupply
    - 91E00 Vehicle Electronics
    - 91F00 C3 & Crew
    - 91G00 Survivability
    - 91H00 Mobility
    - 91I00 Sustainability
    - 91J00 Production
  - 92000 Project Management
  - 94000 System Simulation and Modeling
- A0000 Crusader System Test and Evaluation
- C0000 Crusader Data
- D0000 Risk Mitigation and Component Maturation
  - D1100 System Level Risk Mitigation Projects
  - D1200 RLPG Primary Armament Component Maturation Projects
    - D1210 RLPG Thermal Management
    - D1220 Advanced Breech Designs
    - D1230 Combustion Zone Material Compatibility
    - D1240 Igniter Technology
    - D1250 Interior Ballistic Control
    - D1260 RLPG Design & Build
    - D1270 LP Fill & Metering
  - D1400 Automated Ammunition Handling Component Maturation Projects
  - D1D00 Propulsion Component Maturation Projects

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**D. Lessons Learned**

**LESSONS LEARNED - RA/CM EXTENSION**

- The BOE negotiators did not use the RACMe estimate that had been developed in March. The March estimate would have been a good baseline for the negotiations had they been distributed and studied before the BOE negotiations began.
- Before negotiations, distribute the IGCE estimates to the negotiating teams and schedule a session where the negotiators can discuss the estimates with the original IGCE estimators.
- The negotiated scopes of work were to be priced on the IGCE cost model. Summary sheets had been prepared that captured the labor, materials, and travel for each negotiated WBS element. The need for an immediate price estimate for the BOE required that these sheets be used as input for the model. It was difficult to confirm that the summary sheets were accurate and complete. Future negotiations should be summarized in a format that can be easily fed into the pricing model.
- If rapid costing of the estimate is necessary, then the format of input to the pricing model should be made known to the negotiating teams prior to negotiations. The format should clearly represent the summary of the negotiated WBS element and should match the input cells of the model. The negotiators should fill out the input sheets and the model operators should be familiar with the model before the input from the teams arrives.
- The Pittsfield negotiated elements did not include the effort to be contributed by UDLP. Negotiations by separate teams in different locations must be coordinated.
- When negotiations take place in separate locations, care must be taken to ensure that the efforts of all the contributing contractors are included. A more subtle lesson is that as WBS elements are negotiated, those results should be passed to teams whose negotiations are impacted by those just finished. For example, a decision involving a change in hardware quantity or in schedule may affect several WBS elements, and these decisions must be passed immediately to the affected teams.

**38. IGCE REFINEMENT; THE PEO BRIEFING, AUGUST 17, 1995; AND NEGOTIATION SUPPORT**

**A. IGCE Refinement**

The IGCE process and the initial estimate was briefed to the Army Acquisition Executive (AAE) on March 16, 1995. The final estimate was briefed to the Program Executive Officer, Field Artillery Systems (PEO-FAS) on August 17, 1995. Between these dates, the estimate was revised to reflect changes in the WBS and the program vision as well as refinements in the original estimate and in the estimating methodology.



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The first of these changes involved the labor rates used in the model. For the March estimate, the model used an average labor rate for each labor pool within each contractor. These were gleaned from Forward Pricing Rate Agreements (FPRA) and from contractor proposed rates. During March, the FPRAs for all of the contractors were obtained. This information made it possible for the IGCE estimators to look at the work being performed in each of their WBS elements, and to make a judgment as to which labor categories would perform that work. They allocated percentages of the work to specific labor categories. The model created composite labor rates for each labor pool within each WBS element. When these composite rates replaced the average rates, the estimate decreased by several percentage points.

The second revision to the estimate was based on a change in the scope of armament, automotive, and ammunition/other material handling equipment sections of the WBS. IGCE estimators compared these revised efforts with their original assumptions and modified the estimate accordingly.

Another change to the estimate and model was to accommodate the adoption of a revised WBS into the program. The changes were directed by OSD to allow better visibility into the contractor's management process. Estimators weighed the impact of the WBS dictionary changes and adjusted their estimates accordingly. The model was modified to map the original estimate into the new WBS elements.

At the August 17 briefing to the PEO-FAS, the final estimate of phases I & II of the Crusader development was presented. The PEO also approved the use of the IGCE model to support the negotiations for the development contract.

### **B. Summary of the PEO Briefing, August 17, 1995**

#### *i. Title*

The title is: "Crusader Independent Government Cost Estimate for Demonstration Phases I and II - Decision Briefing to Program Executive Officer, Field Artillery Systems by COL Ray Pawlicki."

#### *ii. Purpose*

- Provide the results of IGCE for Crusader development - Phases I and II.
- Obtain PEO approval to use the IGCE model to support negotiations for the development contract.

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### *iii. April - August Activity*

- Increased fidelity of labor rates through work allocation within labor pools.
- Revised model to reflect OSD WBS guidance.
- Revised estimate to reflect updated information from program planning efforts.

### *iv. Conclusions*

- The Army has a robust and supportable IGCE to serve as the Army cost position for the Crusader development contract.
- The IGCE model will be a valuable tool supporting the negotiation of the Crusader development contract.

### *v. Recommendations*

- Approve the Crusader IGCE.
- The PEO should notify the AAE of the final IGCE numbers.

### *vi. Results*

- The Crusader IGCE was approved and used as a baseline for government negotiations with UDLP.
- The AAE was notified of the IGCE status and final numbers.

## **C. Support for the Negotiations**

The first step in preparing for the negotiations was to distribute sections of the estimate to the PMO teams that would be conducting the negotiations. These sections included the details of the estimate with all the assumptions, calculations and bases of reference. The PMO teams reviewed these estimates, comparing their understanding of the effort with that shown in the IGCE. As differences surfaced, these were discussed and adjustments were made to the estimate as needed. These stemmed primarily from information that was available to the PMO team during their recent contact with UDLP. At the PMO's negotiation kick-off meeting on September 21 and September 22, the IGCE estimators met with PMO negotiation team members to explain, in detail, the IGCE estimates and to identify areas in the contractor's plan that had evolved since the IGCE had been written.

Concurrently, the model was being altered to accommodate the PCO in pricing the BOE as it was being negotiated. The main concerns were that the model be able to capture the labor

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estimates at the labor category level and that pricing occur on a daily or hourly basis as the WBS elements were being negotiated.

A modification to the model allowed the entry of specific labor category hours for each contractor into each WBS element. This solution also generated a table that BOE negotiators could use to summarize their estimates. The table was designed to eliminate the confusion and delay between estimators and price modelers that had occurred in RACMe.

### **39. ARMY COST ESTIMATING INTEGRATED TOOLS (ACEIT) AUTOMATED REPORTS**

#### **A. ACEIT Model Development**

ACEIT is an estimating system containing a variety of tools designed to assist cost analysts in conducting cost analysis activities such as cost estimates, what-if studies, cost proposals and evaluations, risk and uncertainty analysis and Cost Estimating Relationship (CER) development.

The initial intention for the IGCE effort was to use ACEIT in two areas: (1) the analysts of the seven IGCE teams would input their estimates into ACEIT using their own computers and (2) the Configuration Control Board (CCB) would be responsible for setting up and maintaining the information architecture system well as combining the ACEIT inputs of the seven teams into one automated IGCE report.

During the initial evaluation of the IGCE estimating process, the IGCE team agreed to use Excel instead of ACEIT in the information architecture system. This decision was based on the complexity of the UDLP team, the goals for presenting the detailed contractor cost structures, and the explicit variable explanation sheets. A description of the Excel model is given in section 30. However, the requirement remained for Army program cost estimates to be presented in ACEIT to allow the Crusader to be properly represented in the Army Cost Database. Therefore, the ACEIT model of the estimate was developed following the completion of the Excel model.

It utilizes a modified version of the full contractor WBS, going down to level 2 and in some areas, level 3. It includes all the Crusader contractor team members with their full cost and burden structures. Labor rates are programmed at the labor pool level. The model includes the documentation of the estimate found in the Excel model, abridged to match the WBS in the ACEIT model. A hard copy of this documentation accompanies the model, as does a brief introduction / user guide.

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**B. Lessons Learned**

LESSONS LEARNED - ACEIT AUTOMATED REPORTS
<ul style="list-style-type: none"><li>• ACEIT lacks the functionality to accomodate an estimate of the size and complexity of the Crusader IGCE.</li><li>• Excel offers the ability to dynamically link multiple worksheets and workbooks into one model. This feature was critical to the support of the decentralized estimating process, the large WBS (444 elements), and the requirement to link the rationale to the pricing of the estimate.</li></ul>



**40. SUMMARY OF KEY LESSONS LEARNED**

SUMMARY OF KEY LESSONS LEARNED
<ul style="list-style-type: none"><li>• On any major project, such as Crusader, start the documentation process early - it's very hard to reconstruct data and history with personnel turnover.</li><li>• The current approach (of mandated teaming/partnering of contractors) has created a teaming agreement which assumes individual companies will "play well together." Experience to date regarding how well they pull together indicates some delay and maneuvering to protect vested interests.</li><li>• Mandating relationships between/among defense contractors may not result in the desired effects. This challenges the IPT approach until all parties are operating in a contractual "comfort zone."</li><li>• IGCE and model process are key to controlling Government understanding of program baseline, costs, changes, and risks.</li></ul>



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## **APPENDIX**

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## GLOSSARY

AAE	-	Army Acquisition Executive
ACEIT	-	Automated Cost Estimating Integrated Tool
ADM	-	Advanced Demonstrator Module
AFAS	-	Advanced Field Artillery System
AGS	-	Armored Gun System
AMC	-	US Army Materiel Command
AMSAA	-	Army Materiel Systems Analysis Activity
APU	-	Auxiliary Power Unit
ARDEC	-	Armament Research, Development, and Engineering Center
ASA	-	Assistant Secretary of the Army
ASA(FM)	-	Assistant Secretary of the Army (Force Modernization)
ASARC	-	Army Systems Acquisition Review Council
ASA(RDA)	-	Assistant Secretary of the Army, Research, Development and Acquisition
ASCO	-	Advanced Systems and Concepts Office
ASM	-	Armored Systems Modernization
ATD	-	Advanced Technology Demonstrator
ATR	-	Automotive Test Rig
ATTD	-	Advanced Technology Transition Demonstrator
AVTA	-	Armored Vehicle Technology Associates
BAFO	-	Best and Final Offer
BCM	-	Business Clearance Memorandum
BFVS	-	Bradley Fighting Vehicle System
BOE	-	Basis of Estimate
C/SCS	-	Cost/Schedule Control System
C/SCSC	-	Cost/Schedule Control System Criteria
C2	-	Command & Control
C2E	-	Command & Control Element
C3	-	Command Control and Communications
CAD	-	Computer Aided Design
CAIG	-	Cost Analysis Improvement Group
CALS	-	Computer Aided Acquisition and Logistic Support
CAM	-	Computer Aided Manufacturing
CARD	-	Cost Analysis Requirements Document
CCB	-	Configuration Control Board
CCDR	-	Contractor Cost Data Report
CCL	-	Combat Configured Load
CDR	-	Critical Design Review
CDRL	-	Contract Data Requirements List
CED	-	Concept Exploration and Development
CEEMD	-	Concept Exploration & Engineering Manufacturing Development
CEP	-	Circular Error Probable

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**GLOSSARY**

CER	-	Cost Estimating Relationship
CITIS	-	Contractor Integrated Technical Information Service
CMV	-	Combat Mobility Vehicle
COCO	-	Contractor Owned Contractor Operated
COEA	-	Cost & Operational Effectiveness Analysis
COMEL	-	Common Elements
CONUS	-	Continental United States
COTS	-	Commercial Off The Shelf
CPIF w/AF	-	Cost Plus Incentive Fee with Award Fee
CRB	-	Cost Review Board
C/SCSC	-	Cost/Schedule Control System Criteria
CSC	-	Conventional Systems Committee
CSCI	-	Computer Software Configuration Item
CSE	-	Common Support Equipment
DA	-	Defense Armament
DAB	-	Defense Acquisition Board
DAE	-	Defense Acquisition Executive
DCAA	-	Defense Contract Audit Agency
Dem/Val	-	Demonstration/Validation
DIS	-	Distributed Interactive Simulation
DoD	-	Department Of Defense
DPICM	-	Dual Purpose Improved Conventional Munitions
DPRO	-	Defense Plant Representative Office
DSMC	-	Defense System Management College
DTC	-	Design To Cost
DTUPC	-	Design To Unit Production Cost
ECS	-	Environmental Control System
EDT	-	Engineering Development Test
EMC	-	Electromagnetic Compatibility
EMD	-	Engineering & Manufacturing Development
EMI	-	Electromagnetic Interference
ESOW	-	Example Statement Of Work
EUT	-	Early User Test
EUTE	-	Early User Test and Experimentation
FA	-	Field Artillery
FAASV	-	Field Artillery Ammunition Support Vehicle
FAR	-	Federal Acquisition Regulation
FARV	-	Future Armored Resupply Vehicle
FDT&E	-	Force Development Test and Experimentation
FIFV	-	Future Infantry Fighting Vehicle

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**GLOSSARY**

FLIR	-	Forward Looking Infra-red Radar
FRP	-	Full Rate Production
FPRA	-	Forward Pricing Rate Agreements
FRACAS	-	Failure Reporting and Corrective Action System
FUE	-	First Unit Equipped
FVS	-	Field Artillery Vehicle System
FY	-	Fiscal Year
G&A	-	General and Administration
GDLS	-	General Dynamics Land System
GFE	-	Government Furnished Equipment
GFP	-	Government Furnished Property
GOCO	-	Government Owned Contractor Operated
GOGO	-	Government Owned Government Operated
HCA	-	Head of Contracting Activities
HE	-	High Explosive
HET	-	Heavy Equipment Transfer
HHA	-	Health Hazard Assessment
HQDA	-	Headquarters Department of the Army
IAT&C	-	Integration, Assembly, Test, and Checkout
IB	-	Interior Ballistics
IGCE	-	Independent Government Cost Estimate
ILS	-	Integrated Logistics Support
ILSMT	-	Integrated Logistics Support Management Team
ILSP	-	Integrated Logistics Support Plan
IM	-	Insensitive Munitions
IMC	-	Integral Midwall Cooled
IMP	-	Integrated Master Plan
IMS	-	Integrated Master Schedule
IOT&E	-	Initial Operation Test & Evaluation
IPD	-	Integrated Product Development
IPR	-	In Process Review
IPT	-	Integrated Products Team
IRD	-	Independent Research and Development
ISP	-	Installation Supply Point
IV&V	-	Independent Verification and Validation
JCS	-	Joint Chiefs of Staff
KE	-	Kinetic Energy



**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

GLOSSARY

LABCOM	-	Laboratory Command
LCC	-	Life Cycle Cost
LLI	-	Long Lead Item
LOSAT	-	Line Of Sight Anti-Tank
LRIP	-	Low Rate Initial Production
LSA	-	Logistic Support Analysis
MAC	-	Modular Artillery Charge
MANPRINT	-	Manpower & Personnel Integration
MANTECH	-	Manufacturing Technology
MBTI	-	Myers Briggs Type Indicator
MCM	-	Multi-Chip Module
MCP	-	Military Construction Plan
MET	-	Meteorological Data
MLRS	-	Multiple Launched Rocket System
MMDS	-	Martin Marietta Defense Systems
MNS	-	Mission Needs Statement
MOFA	-	Multi-Option Fuze for Artillery
MOPP	-	Mission Oriented Protective Posture
MOU	-	Memorandum Of Understanding
MRC	-	Major Regional Conflicts
MRSI	-	Multiple Round Simultaneous Impact
MS	-	Milestone
MV	-	Muzzle Velocity
NATO	-	North Atlantic Treaty Organization
NAV	-	Navigation
NBC/ECS	-	Nuclear Biological and Chemical/Environmental Control System
NBCCS	-	NBC Contamination Survivability
NDI	-	Non-Developmental Items
O&S	-	Operations and Support
OASA(RDA)	-	Office of Assistant Secretary of the Army, Research, Development and Acquisition
OASD	-	Office of Assistant Secretary of Defense
OPM	-	Office of the Project Manager
OPTEC	-	Operational Test and Evaluation Command
ORD	-	Operational Requirements Document
OSD	-	Office, Secretary of Defense
PA&E	-	Program, Analysis and Evaluation
PALT	-	Program Acquisition Lead Time
PARC	-	Principal Authority for Contracting Activities

**Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

**GLOSSARY**

PCO	-	Procuring Contracting Officer
PDM	-	Program Decision Memorandum
PDR	-	Preliminary Design Review
PDT	-	Product Development Team
PDUSD	-	Principal Deputy Under Secretary of Defense
PEO	-	Project Executive Office
PGM	-	Program Guidance Memorandum
PLS	-	Palletized Loading Systems
PM	-	Project Manager
PMO	-	Program Management Office
POC	-	Point of Contact
POE	-	Program Office Estimate
POL	-	Petroleum, Oils, Lubricants
POM	-	Project Objective Memorandum
PRS	-	Production Readiness Strategy
PSE	-	Peculiar Support Equipment
PTS	-	Projectile Tracking System
QA	-	Quality Assurance
R/M	-	Reliability/Maintainability
RA	-	Requirements Analysis
RACM	-	Requirements Analysis Component Maturation
RACMe	-	Requirements Analysis/Component Maturation Extension
RAM	-	Reliability, Availability, Maintainability
RFP	-	Request For Proposal
RLPG	-	Regenerative Liquid Propellant Gun
RSOP	-	Reconnaissance, Surveillance and Occupation of Position
RSTA	-	Reconnaissance, Surveillance and Target Acquisition
RSV	-	ReSupply Vehicle
SAIC	-	Science Application International Corporation
SAR	-	Selective Acquisition Report
SBP	-	Supplemental Ballistic Protection
SCE	-	Software Capability Evaluation
SDR	-	System Design Review
SDT	-	System Development Team
SE&I	-	System Engineering and Integration
SEIT	-	Systems Engineering and Integration Team
SIF	-	System Integration Facility
SIL	-	System Integration Laboratory
SLICC	-	Senior Level Integrated Product Team Coordinating Council
SLID	-	System Level Integration Demonstrator

## **Additional Lessons Learned, Updating, and Notes for Crusader**

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**NOTES**

## GLOSSARY

SMAC	-	Smart Munitions Analysis Code
SMI	-	Soldier Machine Interface
SOW	-	Statement Of Work
SPC	-	Statistical Process Control
SPH	-	Self-Propelled Howitzer
SRA	-	Systems Requirements Analysis
SRR	-	System Requirements Review
SRV	-	Survivability
SSA	-	Source Selection Authority
SSAC	-	Source Selection Advisory Council
SSEB	-	Source Selection Evaluation Boards
SSMP	-	System Safety Management Plan
ST&E	-	System Test and Evaluation
T&E	-	Test & Evaluation
T&WV	-	Tracked and Wheeled Vehicle
TACOM	-	Tank Automotive Command
TCM	-	Teledyne Continental Motors
TDP	-	Technical Data Package
TPM	-	Technical Performance Measures
TRADOC	-	U.S. Army Training and Doctrine Command
TTFC	-	Tactical and Technical Fire Control
TVS	-	Teledyne Vehicle Systems
UDLP	-	United Defense Limited Partnership
USABRL	-	Unit Staff Army Ballistics Research Laboratory
USACEAC	-	United States Army Cost & Economic Analysis Center
USD (A&T)	-	Under Secretary of Defense for Acquisition and Technology
VD&C	-	Video Distribution and Control
VETRONICS	-	Vehicle Electronics
VP	-	Virtual Prototype
VTC	-	Video Teleconference
WBS	-	Work Breakdown Structure

**Additional Lessons Learned, Updating, and Notes for Crusader**

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